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The Refinement and Development of the Project FLAME Intervention

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Declaration of Authorship

"This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism."

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Date: *1st of October 2020*

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Abstract

The Refinement and Development of the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) Intervention

Brian Donovan

Introduction: Recent research in Ireland has shown that adolescents display poor motor competence levels across both fundamental movement skills and functional movement patterns. Physical Education (PE)-based interventions delivered by specialist PE teachers can have a positive impact on youths' motor competence (MC).

Purpose: The purpose of this thesis is to complete a formative evaluation towards refining and developing the original Project FLAME intervention to progress to its next stage of development via the expansion of its quantitative evidence base, and the refinement of the intervention and its resources based on qualitative feedback from pre-service PE specialist teachers.

Methods: Study 1 entailed the collection of cross-sectional MC data amongst Irish adolescent youths across years 1 – 3 of post-primary school (N = 373; 178 girls; mean age = 14.38 ± 0.86 years). Actual MC data was collected across ten Fundamental Movement Skills (FMS) and seven Functional Movement Screen™ (FMS™) movements. FMS were collected across the locomotor, object control and stability constructs using established testing batteries, namely the Test of Gross Motor Development (TGMD), the TGMD-2, and the Get Skilled: Get Active manual. Functional movement was assessed using the FMS™. Actual MC data were analysed using sex as a

comparative variable across FMS and FMS™. Correlational analysis and chi-square tests were utilised to determine association between the movement constructs and dysfunctional movement prevalence, respectively. Study 2 adopted qualitative methods via a focus group (FG) discussion conducted with six pre-service teachers following their participation in a Project FLAME Continuing Professional Development (CPD) style workshop. The FG discussions focussed on two topics: 1) adolescent MC, and 2) perceptions of Project FLAME and its resources. Thematic analysis of the data was then conducted.

Results: Study 1 suggested that Irish adolescents display 1) low levels of MC proficiency across FMS and FMS™; 2) sex-based differences across both MC constructs; 3) high levels of dysfunctional movement; 4) a moderate association between their overall performance of FMS and FMS™. Study 2 found that the practising pre-service PE specialist teachers believed that sport participation and physical activity (PA) had a significant impact on their students' MC, that MC was generally low and declined with age, and that a substantial MC proficiency gap was evident between high and low skilled adolescents. The participants showed support for Project FLAME and its resources as a facilitator of their pedagogical practice and suggested practical amendments (for example, putting QR code video links next to their relevant activity in the Project FLAME handbook) which would enhance the resource's practicality and accessibility.

Discussion: Overall, this thesis suggested that quantitative evidence of actual MC deficiency is apparent in Irish adolescents which is corroborated by qualitative data from practising pre-service PE specialist teachers, highlighting

the need for effective MC interventions such as Project FLAME to ameliorate this deficiency. The increased scale and diversity of actual MC testing further developed Project FLAME's evidence base. The association of FMS and FMS™ in Irish adolescents reinforces the foundations of the Project FLAME intervention in its inclusion of both MC constructs together. These results have been used to make refinements and developments to the original Project FLAME, and its resources, informing the development of a new iteration. This new iteration will be used in Project FLAME's next phase as it undergoes a randomised controlled trial (RCT).

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List of Abbreviations

AfL	Assessment for Learning
ASLR	Active Straight Leg Raise
BMI	Body Mass Index
CAPL	Canadian Assessment of Physical Literacy
CPD	Continuing Professional Development
CSPPA	Children's Sport Participation and Physical Activity Study
DEIS	Delivering Equality of Opportunity in Schools
EC	Early Childhood
FLAME	Fundamental and Functional Literacy for Activity and Movement Efficiency
FMS	Fundamental Movement/Motor Skills
FMS™	Functional Movement Screen™
HALO	Healthy Active Living and Obesity Research Group
HBSC	Health Behaviour in School-aged Children
KTK	Körperkoordinationstest für Kinder
LC	Late Childhood
M	Mean
MC	Middle Childhood
MC	Motor Competence
MQ	Motor Quotient
MVPA	Moderate-to-Vigorous Physical Activity
NCCA	National Council for Curriculum and Assessment
PA	Physical Activity
PE	Physical Education
PL	Physical Literacy
PMC	Perceived Motor Competence
PSC	Perceived Self-Confidence
QR	Quick Response
RCT	Randomised Controlled Trial

SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
SREC	Social Research Ethics Committee
TGMD	Test of Gross Motor Development
TGMD-3	Test of Gross Motor Development-3
TGMD-2	Test of Gross Motor Development-2
TSPU	Trunk Stability Push-Up
UCC	University College Cork
WHO	World Health Organization
Y-PATH	Youth Physical Activity Towards Health

Chapter I: Introduction to Thesis

1.1 Publications and Conference Proceedings

1.1.1 Journal Article – Published

Philpott, C., **Donovan, B.**, Belton, S., Lester, D., Duncan, M., Chambers, F., & O'Brien, W. (2020). **Investigating the age-related association between perceived motor competence and actual motor competence in adolescence.** International Journal of Environmental Research and Public Health, 17(17), 1–18. https://doi.org/10.3390/ijerph17176361

1.1.2 Journal Article – Submitted to Journal

Donovan, B., Philpott, C., Lester, D., Chambers, F., Belton, S., & O'Brien, W. (2020). **An Investigation of Fundamental Movement Skills and Functional Movement in Irish Adolescents: Proficiency Levels and Relatedness.** Journal of Motor Learning and Development.

1.1.3 Journal Article – Revise and Resubmit

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1.2 Background to Research Area

Reducing adolescent physical inactivity has become a key goal of the World Health Organisation's (WHO) 'Global Action Plan on Physical Activity 2018-2030', targeting a 15% relative reduction in physical inactivity by 2030 (World Health Organisation, 2018). The World Health Organization (2010) outlined that health benefits can be achieved by exceeding the guidelines of 60 minutes MVPA per day. PA has been linked to the prevention of chronic

diseases such as cancer, cardiovascular disease, diabetes, obesity, osteoporosis, and depression (Warburton, Nicol, & Bredin, 2006). Conversely, physical inactivity is associated with increased risks of adverse health conditions and also carries a significant economic burden (Kumar, Robinson, & Till, 2015; Lee et al., 2012). Indeed, Kumar et al. (2015) noted that there exists an inverse correlation between PA participation and all-cause mortality, with PA acting as a potent medicine for the healthy development of adolescents.

Over the past decade, the percentage of Irish post-primary students meeting moderate-to-vigorous physical activity (MVPA) guidelines (at least 60 minutes MVPA per day (Department of Health & Department of Transport Tourism and Sport, 2016) has declined from an already low 12% in 2010, to just 10% in 2018 (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010; Woods et al., 2018). For comparison, a worldwide study completed in 2016 found that levels of adolescent physical inactivity (i.e. not meeting 60 minutes of MVPA per day) were at 78.4% for boys, and 84.4% for girls, which was described as 'extremely high' inactivity (Sallis et al., 2016). Given that 90% of Irish adolescents in 2018 are not meeting the recommended guidelines for being physically active (Woods et al., 2018), it appears that physical activity (PA) levels are at a critically low level in Irish adolescent youth.

According to the Children's Sport Participation and Physical Activity (CSPPA) study (2018), 25% of Irish post-primary students presented with an unhealthy Body Mass Index (BMI) score. Across the sub-sample (primary and post-primary together), 20% of Irish youths were classified as being overweight and 6% were classified as being obese, with < 1% presenting as

underweight (Woods et al., 2018). PA during adolescence can serve an effective role in the prevention of overweight and obesity in children (De Bourdeaudhuij et al., 2013). Recent research has called for urgent action to be taken via interventions which target adolescent youths to keep them involved in PA and promote PA amongst this vulnerable population (Belton, O'Brien, Meegan, Woods, & Issartel, 2014; Guthold, Stevens, Riley, & Bull, 2020). Previous research has established strong links between Motor Competence (MC) and PA in youths (Holfelder & Schott, 2014; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Strategies such as the development of adolescent's MC have been identified as a potential avenue through which PA levels can be improved in adolescents (Belton et al., 2014; Lima et al., 2017).

Robinson et al. (2015) described MC as goal-directed human movement, also outlining that the term can be reflective of various terminologies such as motor proficiency, fundamental movement/motor skill, and motor co-ordination, for example. MC itself has been associated with skill-related physical fitness (e.g. agility, balance, co-ordination, speed, power; Haga, 2008; Haugen & Johansen, 2018; Utesch, Bardid, Büsch, & Strauss, 2019), and the overall concept of health-related physical fitness (i.e. cardiorespiratory and musculoskeletal fitness; Utesch et al., 2019). According to systematic analysis by Cattuzzo et al. (2016), strong evidence exists for positive associations between MC and cardiorespiratory fitness, as well as musculoskeletal fitness. Given the numerous benefits of MC for young people, the assessment of MC in youths deserves careful consideration (Bardid, Vannozzi, Logan, Hardy, & Barnett, 2019).

Conceptually, Project FLAME is founded on Stodden et al's. (2008) developmental model, which theorises that MC plays a vital role in youth's development through its dynamic and reciprocal relationship with PA as youths grow. This theory asserts that the relationship between MC and PA act reciprocally, strengthening over time to create either positive spirals of PA engagement and improved MC or, alternatively, negative spirals of PA disengagement and poorer MC levels. The creation of these continuously compounding spirals will have consequences for youth's weight status and risk of obesity, with positive spirals leading to a healthy weight status and negative spirals leading to an unhealthy weight status. This theory has been reinforced by empirical evidence via a 7-year longitudinal study which demonstrated that a clear positive feedback loop exists between MC and PA (Lima et al., 2017).

Fundamental Movement/Motor Skills (FMS) is a popular term used in reference to MC, which represents an aspect of MC (Logan, Ross, Chee, Stodden, & Robinson, 2018). These are the 'building blocks' of more advanced movements and typically developing youths should have the capacity to acquire these gross motor skills by the age of six (Gallahue, Ozmun, & Goodway, 2012). Despite this, FMS research in Ireland to date has shown that Irish youth (both children and adolescents) continue to display poor levels of FMS proficiency (Behan, Belton, Peers, O'Connor, & Issartel, 2019; Belton et al., 2014; Kelly, O'Connor, Harrison, & Ní Chéilleachair, 2018; O' Brien, Belton, & Issartel, 2016). This is concerning, given the strong evidence that FMS competency is positively associated with PA in both children and adolescents (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). It is particularly worth noting that a plateau and decline in FMS development has been identified amongst

Irish youth around the ages of 10 - 12 years old around the onset of adolescence (Behan et al., 2019).

Sex-related differences in FMS proficiency have been consistently noted in research, with males outperforming females in object control related FMS (e.g. kicking and throwing; Breslin, Murphy, McKee, Delaney, & Dempster, 2012; O' Brien et al., 2016), and females generally outperforming males in locomotor skills (e.g. running and skipping; Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). Importantly, a Singaporean study of children found no significant sex-related differences in FMS proficiency which they attribute to the Singaporean lower primary school curriculum's equal sexopportunities. It is important to understand and appreciate how FMS manifests itself in different populations. This is evident in research by Hardy et al. (2012), who examined populations across both sexand socioeconomic status (SES) and were then able to prescribe interventions based on population need. O'Brien et al. (2016) noted the importance of developing Irish adolescents FMS so that they may have the abilities to fully engage with activities that they choose, and elevate their PA engagement. Further to this, O'Brien et al. (2016) continued to highlight the need to identify and address specific weaknesses in populations through targeted interventions in order to maximise FMS and PA benefits for Irish adolescents.

The poor FMS levels in Ireland are congruent to those reported in in other developed nations such as England (Foweather, 2010), Singapore (Mukherjee, Lye Ting Ching, & Fong, 2017), and Australia (Van Beurden et al., 2003). In the past decade, these poor levels of FMS proficiency have begun to be examined and acted upon by Irish researchers who have

developed targeted, multi-component interventions which aimed to address low PA through developing FMS in adolescents (Belton, McCarren, McGrane, Powell, & Issartel, 2019; Belton et al., 2014) and in younger children (Bolger et al., 2018). Early Project FLAME research identified that not only do Irish adolescents display poor FMS ability, they also perform poorly in the area of functional movement (Lester et al., 2017).

O'Brien et al. (2018) highlighted the need to understand both fundamental and functional movement during adolescence in order to garner a more comprehensive understanding of motor development, as both concepts are indicative of adolescent's MC. Functional movement is commonly assessed through the Functional Movement Screen™ (FMS™; Cook, Burton, Fields, & Kiesel, 1998; Cook, Burton, & Hoogenboom, 2006b, 2006a), which consists of foundational strength, mobility and stability dependent movements (e.g. the squat, in-line lunge, and trunk stability push up; Abraham, Sannasi, & Nair, 2015). To the author's knowledge, only one recent research study (Wu, Eungpinichpong, Ruan, Zhang, & Dong, 2020) has examined the association of FMS™ and FMS (using the TGMD-2) in youth, although this study examines children rather than adolescents, is preprint, and not yet peer-reviewed. Silva et al. (2019) examined the association between FMS™ performance and MC in young adults (73.9% male; mean age = 21.2 years), finding that functional movement was associated with the stability construct of MC.

Functional movement research in Ireland is still in its infancy, however, there are some studies which have begun to examine this area of MC in Irish adolescents (Lester et al., 2017; O'Brien, Duncan, et al., 2018). There appears

to be some sex differences present in specific functional movements, for example, females have been found to outperform males in the active straight leg raise (O'Brien, Duncan, et al., 2018), whereas males were found to display greater proficiency in the trunk stability push-up (Abraham et al., 2015; Anderson, Eumann, & Huxel Bliven, 2015). Following findings of low levels of functional movement in Irish adolescents, Lester et al. (2017) suggested that the development of a specifically tailored movement-oriented intervention, targeting FMS and functional movement through Physical Education (PE), would be a timely addition to the field.

Teacher-led PE-based interventions have previously demonstrated success in the improvement of both FMS (Chan, Ha, Ng, & Lubans, 2019; McGrane, Belton, Fairclough, Powell, & Issartel, 2018) and functional movement proficiency (Coker, 2018). Morgan and colleagues' (2013) systematic review asserted that PE plays a pivotal role in the development of youth FMS and that teachers and/or PE specialist teachers, with appropriate professional development are needed to enact these intervention programmes. Providing adequate resources and support for teachers to implement interventions is essential (Belton et al., 2014). The importance of working with PE specialist teachers in developing initiatives to enhance student movement is demonstrated by Lander et al. (2016), who qualitatively assessed 18 PE specialist teachers' opinions on a new motor skill assessment tool. Through examining the qualitative data, researchers discerned PE teachers' support for the tool and were able to identify alterations for the tool's use to enhance its practicality as pedagogical instrument.

PE-based, multi-component interventions which adopt a whole-school approach, such as the Youth Physical Activity Toward Health (Y-PATH) intervention, have demonstrated success in the Irish context (Belton, McCarren, et al., 2019). The Y-PATH intervention highlights the need to target three components/stakeholders in particular, namely the student, the teacher, and the parent/guardian (Belton et al., 2014). Timperio and colleagues'. (2004) review highlighted that the adoption of whole-school approaches (curriculum, policy and environment) were more effective than those which changed curricula only. Pertinently, Lai et al. (2014) asserted that one must enact strategies that facilitate promising interventions to be self-sustainable without the need for researcher support.

1.3 Research Aims

The aim of this formative research is to further the refinement and development of the Project FLAME movement-oriented intervention by expanding the scope of the MC evidence base and refining the project based on the views of practising pre-service PE teachers.

1.4 Research Objectives

1. Measure and report on Irish early adolescents' MC levels across both FMS and functional movement in a large and diversified sample population.
2. Examine whether any association exists between FMS and functional movement proficiency in Irish adolescents.
3. Assess the views and opinions of practising pre-service PE teachers following Project FLAME professional development style training.

4. Incorporate the views of practising pre-service PE teachers into the refinement of Project FLAME, specifically to inform the development of a revised intervention for a Randomised Controlled Trial.

1.5 Thesis Structure

- Chapter I entails a brief introduction to the research, the basis for the development of Project FLAME, statements of the research aims, and overview of the contents of this thesis document.
- Chapter II is a review of the literature, as relevant to this research project, which includes literature on MC, PA, FMS, functional movement, Perceived Motor Competence (PMC), Physical Literacy (PL), and research on PA/MC interventions.
- Chapter III is a quantitative research paper which reports on Irish adolescents' FMS and functional movement proficiency and investigates whether there exists a relationship between the MC constructs of FMS and functional movement.
- Chapter IV is a qualitative research paper which outlines refinements made to Project FLAME based on feedback from pre-service PE teachers practising in socioeconomically disadvantaged schools.
- Chapter V concludes this research thesis and outlines recommendations for the future development of Project FLAME.

1.6 Research Team

- Lead Researcher: Dr. Wesley O'Brien:
    - Responsible for overseeing the project and advising the two postgraduate researchers.
- Co-Supervisor: Dr. Sarahjane Belton
    - Responsible for advising the postgraduate research team on operational and technical issues.
- Postgraduate Researcher 1: Mr Brian Donovan
    - Responsible for planning and execution of the research project, collecting, collating, and interpreting data.
- Postgraduate Researcher 2: Mr Conor Philpott
    - Responsible for planning and execution of the research project, collecting, collating, and interpreting data.
- Research Assistants:
    - Responsible for aiding in the collection of data.

Chapter II: Review of Literature

2.1 Motor Competence - Overview

Motor Competence (MC) is described as an ability to perform both fine (e.g. throwing darts) and gross motor skills (e.g. kicking a ball; Haga, 2008). Utesch et al. (2019, p. 543) elaborated further on this definition by specifying that MC also comprises of *"the underlying mechanisms including coordination, control, and quality of movement".* Robinson et al. (2015) outlined that MC is a global term which describes goal-directed human movement, and Bardid et al. (2019) suggested that the term pertains to an individual's proficiency in executing motor skills. In their meta-analysis of correlates of gross MC, Barnett et al. (2016) identified four aspects of gross MC; object control (e.g. kicking, catching), locomotor (e.g. running, jumping), stability (e.g. balancing) and motor coordination (utilising muscles synergistically; Darby & Frysztak, 2013). Logan et al. (2018) purport that MC is often referred to as Fundamental Motor Skills and that Fundamental Motor Skills may be used interchangeably with Fundamental Movement Skills (FMS) which is supported in the work of Barnett et al. (2016, p. 1664), who suggested that 'gross motor competence' as a 'global term' is used describe FMS, stability or motor co-ordination. Barnett et al. (2016) also outlined that FMS exists as part of a broad spectrum of MC, which echoes Haga's (2008) description of MC containing both gross and fine motor skills.

Hulteen et al. (2018) discussed the importance of developing and maintaining MC across the lifespan, including both FMS and functional movement capacity under the term MC. Hulteen et al. (2018) proposed a new

term called ‘foundational movement skills’, which broadens the scope of FMS to include any goal directed movement pattern that contributes to an individual’s ability to be physically active. This suggests that MC can be viewed as an umbrella term under which several movement and motor terms exist including FMS and functional movement.

2.1.1 Motor Competence - Proficiency Levels

Research in Westernised countries over the past few decades has identified a downward trend in youth MC proficiency, across FMS and functional movement (Foweather, 2010; O’Brien, Duncan, et al., 2018; Okely & Booth, 2004). Bardid et al. (2015) completed a cross cultural study (N = 496, age range 6-8 years) between Australian and Belgian children, noting that both samples reported significantly lower MC levels than results from studies conducted forty years ago. In a large scale, longitudinal study (N = 13’752, age range = 9 – 15 years), Hardy et al. (2013) noted a consistently low level of MC in the FMS category across a 13-year span (1997-2010) in Australian children. While FMS proficiency remained low, results, however, showed an increase in children’s FMS proficiency between 1997 and 2004, which was specifically attributed to policy change supporting FMS teaching in Australian schools.

2.1.2 Motor Competence Theoretical Models: Stodden’s Developmental Model

Stodden and colleagues (2008) theorised a developmental model (Figure 2.1) that asserts that MC has an important reciprocal relationship with PA throughout childhood, showing how the relationship between MC and PA strengthens over time. The theory posits that PA engagement will positively develop MC in early childhood and that this developed MC will then lead to

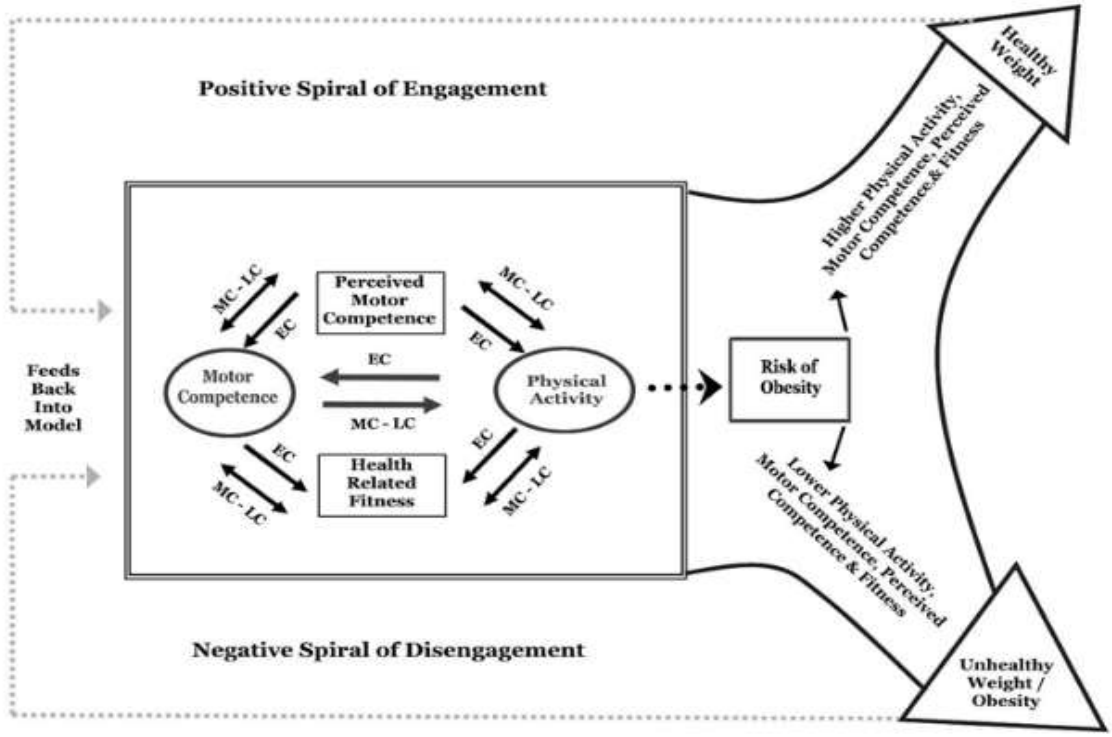

Figure 2.1: Developmental Mechanisms Influencing Physical Activity Trajectories of Children (Stodden et al., 2008, p. 294).

more PA, although this relationship is mediated by individual's perceived motor competence (PMC), and their health-related fitness. The developmental model suggests that feedback loops may be created; for example, a child who is physically active may develop MC, which in turn leads to higher PA and a positive spiral of engagement in activity, leading to associated health benefits such as a healthy weight status. The opposite may also occur where an individual enters a negative spiral of disengagement, caused by low PA and poor MC which leads to obesity and a continuously compounding disengagement with PA.

Stodden and colleagues' (2008) theory has been tested in a longitudinal study which found that a clear feedback loop exists between MC and PA through childhood and into early adolescence (Lima et al., 2017). Cohen et al. (2014) asserted that in school settings, the more skilful children may dominate

active object control games, such as basketball and soccer, thus increasing their own activity levels and creating/reinforcing the divide between low and highly skilled children. Barnett et al. (2011) purported that the reciprocal relationship or 'feedback loop' between MC and PA exists in relation to object control, and that, further to the belief that MC leads to increased PA, increased PA may also be a factor in supporting continued motor development for children and adolescents. This highlights the importance in creating a positive cycle of engagement in youth, so that they may derive the health benefits associated with PA.

2.1.3 Motor Competence Theoretical Models – Gallahue, Ozmun, and Goodway's Triangulated Hourglass Model

The Triangulated Hourglass heuristic device, as shown below in Figure 2.2, represents the theoretical model of lifelong motor development (Gallahue et al., 2012). The model gives a general outline of the different stages of motor development, which an individual may experience from birth and throughout their life, with general age brackets for each stage (Gallahue et al., 2012). The model illustrates how motor development generally progresses in phases. Beginning with the infantile basic reflexive movements phase, a child may progress to the early childhood rudimentary movements phase. Following these phases, the child may further progress to the fundamental movement phase where youths develop FMS such as kicking, catching, throwing, jumping, and running. Finally, having reached proficiency in the fundamental movement phase, an individual may progress to more advanced, sport specialised movements, as related to their mastered fundamental movements.

An important consideration at this stage is that of Seefeldt et al. (1982), who previously proposed the existence of a ‘proficiency barrier’ which means that, unless proficiency is achieved in these fundamental movements, an individual may be inhibited from progression to more specialised sports skills, on account of the child being less likely to engage in PA (De Meester et al., 2018; Seefeldt & Haubenstricker, 1982). Evidence for the existence of a MC ‘proficiency barrier’ was found by De Meester et al. (2018) who found that 90% children whose actual MC was below the average threshold were not meeting PA guideline for health. Gallahue, Ozmun and Goodway (2012) noted that although MC is age related, the process is not entirely age dependent, and as such, an individual of any age may or may not progress to different stages of development. This sentiment is supported by Rodrigues et al. (2016) who asserted that all children do not necessarily improve in their MC over time, and some may even regress in terms of their motor development over time. Gallahue, Ozmun and Goodway’s (2012) theory of motor development can be viewed in line with the Stodden et al. (2008) model, particularly the critical need to engage youth in positive MC experiences, allowing children and youth to progress towards lifelong advanced skill utilisation. The fundamental phase of motor development appears to be a critical juncture at which proficiency in the FMS becomes essential towards allowing an individual deriving lifelong benefit through their ability to complete specialized movements.

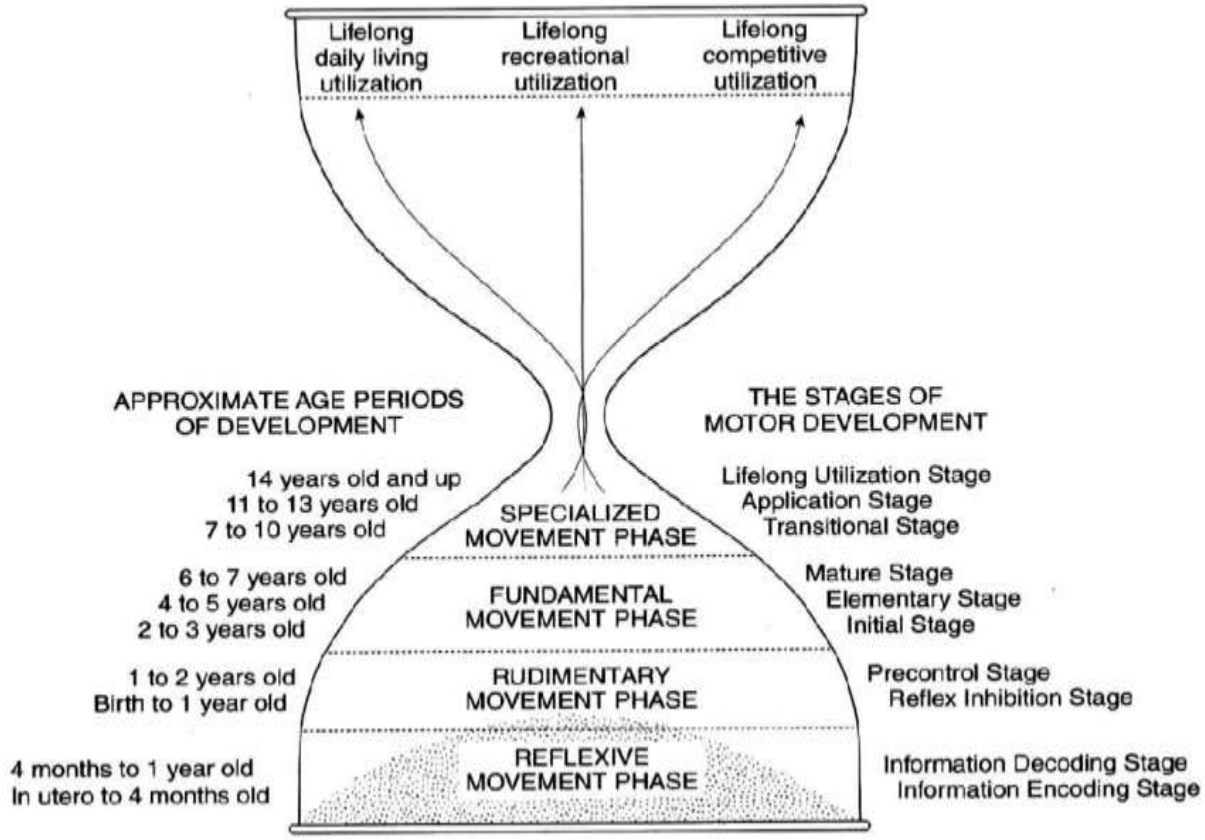

Figure 2.2: Gallahue & Ozmun's Triangulated Hourglass Model (Gallahue & Ozmun, 2012).

2.1.4 Motor Competence – Assessments

Several assessment tools are currently in use, which are designed to assess MC, particularly in young people (Cools, Martelaer, Samaey, & Andries, 2009). MC assessments are generally either; (a) process assessments, which evaluate how a movement is performed (i.e. did they demonstrate a criteria of quality such as bending knees during jump landing), (b) product assessments, which evaluate the outcome of a movement (e.g. how fast a sprint was completed), however, in certain instances, assessment tools may sometimes be a combination of both process and product measures (Cools et al., 2009; Logan, Barnett, Goodway, & Stodden, 2017). Three MC assessment tools commonly used research in youth are the Test of Gross Motor Development-2 (TGMD-2; Ulrich, 2000) as well as its newest iteration

the Test of Gross Motor Development-3 (TGMD-3; Ulrich, 2016), the Körperkoordinationtest für Kinder (KTK; Kiphard & Shilling, 1974, 2007) and the Movement Assessment Battery for Children – 2 (MABC-2; Henderson, Sugden, & Barnett, 2007), which are discussed in greater detail below.

Bardid et al. (2019) published a flow chart to aid researchers to select the most suitable MC research assessment tool, while asserting that there exists no 'gold standard' measure for assessing MC. The authors of this study suggest that objective measures of observation and motion devices provide accurate direct reflections of holistic actual MC, while subjective measures (e.g., self-report) provide an efficient, and indirect measure of MC. The authors concluded that the study purpose, population, and instrument feasibility should be the primary considerations when deciding on the selection of a MC assessment tool. A recently published comparison of process and product assessments of MC by Hulteen et al. (2020) asserted that MC assessment choice should be made based upon the assessment's established validity and reliability, as well as how it aligns to the proposed research questions. In their evaluation of MC assessment measures across childhood, Logan et al. (2017) concluded that the use of both process and product measures of MC should be used to achieve a comprehensive assessment of MC levels, a sentiment which is echoed by Rudd et al. (2016), who suggested using a wide range of test batteries to assess MC. An Australian study by Lander et al. (2016) adopted a pedagogically oriented viewpoint as they sought to address low levels of FMS proficiency in adolescent females by utilising qualitative research methods (e.g. focus groups) to explore specialist PE teacher's opinions of an FMS testing tool for a school setting.

2.1.4.1 Test of Gross Motor Development

A commonly used youth MC assessment tool is the TGMD (Ulrich, 1985). The TGMD is now available in three editions, the original TGMD (Ulrich, 1985), the commonly utilised second edition TGMD-2 (Ulrich, 2000), and the most recent edition of the TGMD-3 (Ulrich, 2016). The TGMD-2 is an assessment of gross motor skills (Logan, Robinson, Rudisill, Wadsworth, & Morera, 2014), widely used in FMS assessments for children and adolescents in Ireland (Bolger et al., 2018; Farmer, Belton, & O'Brien, 2017; Lester et al., 2017; McGrane et al., 2018; O' Brien et al., 2016). The TGMD-2 has also been found to be a valid and reliable measurement tool cross-culturally, in countries such as Portugal (Vítor P Lopes, Saraiva, & Rodrigues, 2018), South Korea (Kim, Kim, Valentini, & Clark, 2014) and Brazil (Valentini, 2012).

The TGMD was created for the purpose of assessing the motor behaviour in children aged between 3 - 10 years of age, to identify those with motor development issues which could lead to lifelong motor skill problems if not ameliorated (Cools et al., 2009; Ulrich, 2000). Recent research in Ireland, however, has demonstrated that early adolescents do not display proficiency when assessed using the TGMD-2 (Farmer et al., 2017; Lester et al., 2017; O' Brien et al., 2016). It has been purported that there is a potential ceiling effect noted with the TGMD-2 usage (Logan et al., 2017), which may in part explain some of the proficiency findings observed in early adolescents across Ireland.

Logan et al. (2014) recommended that PE teachers administer the TGMD-2 as an annual or bi-annual test to detect delayed motor development in young people. The TGMD-2 is a process-based measure which involves the assessment of twelve gross motor skills, which are divided into two subsets;

object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll) and locomotor (run, gallop, hop, leap, horizontal jump and slide; Ulrich, 2000). The testing procedure involves a verbal description of the relevant skill, and an accurate skill demonstration (which may be repeated). Following this, participants perform one unscored practice trial and two test trials which are scored against the specified criteria for the skill. The criteria are summed for each trial and the participant is then given a score for this skill.

The TGMD-2 has been previously criticised for its sensitivity to skill detection, when compared to other measures, such as the Get Skilled; Get Active tool (Logan et al., 2017). Hulteen et al. (2020) found statistically significant associations between the TGMD-2 (kick, throw and run skills only) process measures and product measures of MC, however, the associations were more frequent in the kick and throw measures. Interestingly, the authors found that both the TGMD-2 and product MC were poor at explaining pedometer measured PA variance.

2.1.4.2 Movement Assessment Battery for Children

The MABC-2 is a MC assessment tool, which is used to identify and describe motor performance impairments in youths aged 3 through to 16 years of age (Brown & Lalor, 2009; Cools et al., 2009). The assessment tool is a second iteration of the original MABC, which was designed in the early 1990s (Henderson & Sugden, 1992), and was based on earlier assessment measures from the Test of Motor Impairment (Stott, Moyes, & Henderson, 1972), and the later Test of Motor Impairment – Henderson Revision (Stott, Moyes, & Henderson, 1984). The MABC-2 has been utilised in several studies

as a measure of MC in young people (Clark, Barnes, Duncan, Summers, & Stratton, 2019; Gísladóttir, Haga, & Sigmundsson, 2019).

The MABC-2 contains three sections in total: the physical test, a practitioner observation checklist assessment, and an ecological intervention design manual for developing individual child skills (Pearson Education Ltd, n.d.). The MABC-2 directly assesses MC through motor tasks across three categories: manual dexterity, aiming and catching, and balance, with each category containing eight tasks. The tasks are differentiated based on the age-bracket relevant to the participant: 3-6 years old, 7-10 years old, and 11-16 years old. Standard scores can be derived from each task, which can then be summed to create an overall test score. A total score is derived by summing the scores from each of the categories, and these can be referenced against a traffic light system, which specifically flags individuals within a red zone, amber zone, or green zone (based on their percentile against the normative values). The red zone indicates significant movement difficulty, the amber zone indicates risk of movement difficulty, and the green zone indicates no detection of movement difficulty (Brown & Lalor, 2009; Clark et al., 2019).

The MABC-2 checklist has been shown to meet the standards required for validity and reliability, and demonstrates an ability to discriminate between children with and without motor impairments (Schoemaker, Niemeijer, Flapper, & Smits-Engelsman, 2012). Few studies, however, have been carried out to investigate the validity/reliability of the motor task components of the MABC-2. This has been attributed to the MABC-2's reliance on previous validity attained by the original MABC (Brown & Lalor, 2009). Since several alterations (including new motor task additions) have been made to the motor

tasks section of the original MABC in the MABC-2, the MABC-2 motor tasks could now be considered a new discrete test which should be evaluated for validity and reliability (Brown & Lalor, 2009). A study of Greek pre-school aged children (N = 183, 98 boys, aged 36 – 64 months), however, reported that age band 1 of the MABC-2 is a reliable and valid tool for assessing motor impairment amongst 3 - 5 year olds (Ellinoudis et al., 2011). Both the MABC-2 and the TGMD-2 were juxtaposed in a more recent study by Logan et al. (2014) who reported that both assessments measure different aspects of MC, and shouldn't be used interchangeably, however, given their alignment in some elements (Developmental Co-Ordination Disorder and Delayed Motor Development detection), they may be used complementarily.

2.1.4.3 Körperkoordinationtest für Kinder

The KTK is a product-based assessment that refers to normative values, which assesses gross bodily control, coordination and dynamic balance skills, for children aged 5- to 14- years old, who are typically developing, as well as those with learning difficulties (Cools et al., 2009). The modern KTK is a streamlined version of the original Hamm-Marburger Körperkoordinationstests (Kiphard & Shilling, 1974). This assessment of motor skills has shown evergreen popularity amongst researchers (Iivonen, Sääkslahti, & Laukkanen, 2015). While the KTK remains popular, Bardid et al. (2015) noted that this specific assessment tool is more commonly used in Belgium and European countries, while Australian research often reports much its research through the TGMD-2.

The KTK test has recently been validated for use in children and adolescents in Brazil (Moreira et al., 2019), and has previously demonstrated

moderate associations, when compared to other MC measures in convergent validity research, such as the Bruininks-Oseretsky Test of Motor Proficiency 2 (BOT-2; Fransen et al., 2014) and the original MABC (Smits-Engelsman, Henderson, & Michels, Chris, 1998).

The KTK focusses on the assessment of balance, rhythm, laterality, speed, and agility, through a series of non-sport-specific tasks (Scordella et al., 2015). The test entails four tasks: walking backwards along a balance beam of decreasing width, two-legged lateral jumps for 15 seconds, moving laterally on a wooden board for 20 seconds, and hopping for height with one leg over a 5cm high foam block which increases in height in consecutive 5cm steps (Rudd et al., 2016). At the end of these tasks, the researcher sums the participant's performance result into a motor quotient (MQ), which is the indicator of motor performance. These MQ scores are then compared to normative values, which indicate their categorisation of 'severe motor disorder', 'mild motor disorder' 'normal', 'good' and 'high' (Scordella et al., 2015). Interestingly, although both instruments are deemed measures of MC, a comparative study of the KTK and the TGMD-2 by Rudd et al. (2016) concluded that the tests actually measure discrete aspects of MC.

2.1.5 Motor Competence - Physical Activity and Health Outcomes

MC has been linked to multiple health outcomes, such as increased PA (Lima et al., 2017), physical and health-related fitness (cardiorespiratory fitness and muscular strength) (Luz, Rodrigues, De Meester, & Cordovil, 2017; Utesch et al., 2019), weight status (Robinson, Stodden, Barnett, Lopes, Logan, & Paulo Rodrigues, 2015) and cognitive ability (van der Fels et al., 2015). These findings are supported by research by Wrotniak et al. (2006),

who outline that MC is positively associated with PA participation, and negatively associated with sedentary behaviour in childhood. A further systematic review has purported that there exists associations between various assessments of MC and various measures of health-related fitness (i.e. cardiorespiratory fitness, body weight, and musculoskeletal fitness), and as such, the development of MC in children may enhance the development of long-term health outcomes in children and adolescents (Cattuzzo et al., 2016).

As mentioned previously, the relationship of PA and MC was conceptualised as a reciprocal relationship in the work of Stodden et al. (2008), which was previously theorised by Okely et al. (2001) and has since been validated by the work of Robinson et al. (2015). The associations, however, between MC, PA and weight status have been questioned in a recent meta-analysis by Barnett et al. (2016), who asserted that although associations are present, they depend on how MC is operationalised (e.g. as object control or locomotor MC). Barnett et al. (2009) found that object control proficient youths were more likely to develop into active adolescents This assertion was buttressed and expanded on by Stodden et al. (2014) who suggest that object control proficiency in adolescence may promote sustained PA participation.

Interestingly, Cheng et al. (2016) found that obesity preceded declines in childhood motor skills, and not the inverse. The assertion that obesity precedes declining MC is, however, challenged by Robinson et al. (2015), who found that MC is a precursor, as well as a consequence of weight status. Irrespective, MC has been consistently cited as an important factor in ensuring long term PA through childhood, adolescence and beyond (Barnett et al., 2009; Loprinzi, Davis, & Fu, 2015).

2.2 Physical Activity – Overview

PA can be categorised generally into several different types; aerobic, flexibility, strength, and balance (World Health Organization, 2010). According to Caspersen et al. (1985, p. 126), PA can be defined as “any bodily movement produced by skeletal muscles that results in energy expenditure”. The World Health Organisation (WHO; (2010), specifies that PA for youths (ages 5 – 17 years) includes play, games, sports, transportation and PE. For health, the WHO (2010) recommends that this age group should accumulate at least 60 minutes of Moderate to Vigorous Physical Activity (MVPA) per day, comprising mostly of aerobic activities but including at least 3 bouts of vigorous intensity exercises per week, including exercises which strengthen muscle and bone.

It is also recognised that additional health benefits can be derived from exceeding the recommended level of 60 minutes MVPA/day (World Health Organization, 2010). Hallal et al. (2006) found that adolescent PA had ‘unequivocal’ lifelong benefits for adult health. Further to this, sedentary behaviour in youth was associated with poor adult health outcomes, which outlines the importance of developing healthy behaviours in youth (Hallal et al., 2006).

Pertinently, an Irish research study by Woods et al. (2012) (N = 902, aged 12 – 18 years) found a positive association between enjoyment of PE and enjoyment of PA, highlighting the importance of good quality, enjoyable PE lessons. Further to this, the study also found that those with higher enjoyment of PA and PE were more likely to meet PA guidelines (Woods et al., 2012). In terms of promoting adolescent PA, Gordon-Larsen, McMurray, and Popkin (2000), proposed that there is substantial evidence that PE is a

vital avenue for increasing PA in adolescents. From youth's own perspectives, a qualitative study on how to improve adolescent PA participation found that adolescents would like unstructured, fun, low cost, local, fun activities in appropriate facilities (James et al., 2018).

2.2.1 Physical Activity – Health and Associated Benefits

Warburton, Nicol, and Bredin (2006) claim that there is 'irrefutable evidence' that regular PA aids in the prevention of chronic diseases such as cardiovascular disease, cancer, diabetes, obesity, depression, and osteoporosis. This assertion is reinforced by the findings of Lee et al. (2012) who purport that physical inactivity was responsible for 9% of premature mortality in 2008. Hills, Andersen, and Byrne (2011) note that adolescence is a precarious time in youths' development, in which obesity may develop due to sexual maturation and a general reduction in PA levels.

Beyond the numerous health benefits, inconclusive evidence has been found that PA and academic performance are related. In their systematic review, Rasberry et al. (2011) found that of the 251 studies examined, 50.5% demonstrated a positive relationship between PA and academic performance, 48% showed an insignificant relationship, and 1.5% demonstrated a negative relationship between both variables. Interestingly, a study of Finnish early adolescents (N = 325; 162 girls, mean age = 13.08 ± 0.25 years) found no association between students' self-reported PA and their academic performance, but did find that their FMS proficiency may be a factor in their academic achievement (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015). In terms of mental health and wellbeing, Biddle and Asare's (2011) review of

reviews reports weak to moderate associations between PA and mental health.

2.2.2 Physical Activity - Irish Youths and Youths Abroad

According to Hills, Andersen, and Byrne (2011), in many Western countries, adolescents simply do not meet the recommended PA guidelines for health, with active behaviour routinely being replaced by more sedentary behaviour. The authors add that without intervention, children nowadays will live less healthy lives than their parents. In Ireland, this seems to be the case as, according to the most recent national 'Children's Sport Participation and Physical Activity' (CSPPA) study, only 10% of post-primary students were meeting were meeting the guideline of 60 minutes of MVPA per day (Woods et al., 2018). Notably, this figure is lower than the previous CSPPA study of 2010 which reported that 12% of post primary students were meeting the guidelines of MVPA, showing a decline in the already low PA levels over the past decade. Children who met or exceeded the 60 minute/day MVPA guidelines were noted to have the best health profiles. Concurrently, one in every four youths were classified as unfit, overweight or obese and presented with elevated blood pressure, highlighting the importance of reaching the guidelines on MVPA (Woods et al., 2010). Efforts are already underway to combat the low and declining levels of PA in Irish post-primary students such as the Y-PATH intervention which has demonstrated significant success in improving daily PA levels in intervention populations (Belton, McCarren, et al., 2019; O' Brien, Issartel, & Belton, 2013).

2.2.3 Physical Activity - Sex, Socioeconomic Status, and Age

2.2.3.1 Sex Differences

Males have displayed higher levels of PA than females in both the 2010 and 2018 CSPPA studies of youth in Ireland (Woods et al., 2010, 2018). A potential cause for this imbalance may lie in the fact that adolescent females in Ireland received less PE time than males (Woods et al., 2012). Other potential causes of this discrepancy may emerge from the fact that Irish adolescent females report lower enjoyment of PA and PE than their male counterparts (Woods et al., 2012) and that negative associations have been found amongst Irish adolescent females' television screen-time and their MVPA (O'Brien, Issartel, & Belton, 2018). Conversely, evidence also exists that shows that high levels of MVPA and sedentary behaviour can co-exist in early adolescents (De Bourdeaudhuij et al., 2013).

It must be noted that sex differences in PA are not a uniquely Irish phenomenon, as Brodersen et al. (2007) found that English male adolescents were more active than their female counterparts and that the reduction in PA in adolescent females was greater than the reduction seen in males across adolescence. Indeed, this finding is consistent with the results of the large-scale, 34 country, Global School-based Student Health Survey (regions included: Africa, Asia, South America, and Middle East) conducted amongst 13 to 15 year olds from 2003 – 2007 (N = 72'845; 47.6% boys) which found that overall, 23.8% of boys and 15.4% of girls met the PA recommendations (60-minutes PA per day five days per week) (Guthold, Cowan, Autenrieth, Kann, & Riley, 2010). An Icelandic study of early adolescents (N = 3270; 49.5% girls, grades 6, 8, and 10) suggested that the sex-based discrepancies

in youth PA could be explained by lower membership and higher withdrawal rates from organised sport, also citing encouragement and support as factors in the discrepancy (Vilhjalmsson & Kristjansdottir, 2003).

2.2.3.2 Socioeconomic Differences

A systemic review of socioeconomic status (SES) and PA found that both variables were associated and that youths of lower SES were not as active as those of higher SES. However, the study suggested that the findings are not all uniform, and that there is no single cause for the discrepancy observed in PA between SES groups (Stalsberg & Pedersen, 2010). This is in line with the findings of a review of adolescent SES and health behaviours literature by Hanson and Chen (2007), which also found that low SES was associated with less PA. In continued research in the area of adolescent SES and PA, Stalsberg et al. (2018) found that the observed disparity between low and high SES groups is mostly as a result of differences in leisure time PA, rather than other forms of PA such as active transport.

According to the Irish Health Behaviour in School-aged Children study (2012) (N = 16’ 060, age range = 9 – 18 years old) youths from lower social classes were more likely to report physical inactivity and middle class youths were more likely to report a full 7 days of activity in the past week. Interestingly, Woods et al. (2012) found that amongst Irish youths, as SES decreased, so too did enjoyment of PA. Further to this, in Ireland, post-primary youths of high SES were the most likely to meet PA guidelines (Woods et al., 2018).

2.2.3.3 Age-Related Differences

A marked decrease in PA levels with age in early adolescence has been empirically demonstrated in an longitudinal study of American 9-15-year olds

(N = 1032; 517 boys) which found that PA levels decreased significantly amongst the participants between the ages of 9 – 15 (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). This is consistent with another large-scale, 5-year longitudinal research study (N = 5863; ages 11 – 16) in England which found a decrease in PA across adolescence, suggesting that this is an international issue (Brodersen et al., 2007). Irish research also reinforces this as outlined by Woods et al. (2018), who found that a decline in PA levels was apparent in early adolescence related to the transition between primary and post-primary schooling. They purport that the new school environment, academic pressure, and increased homework may in part explain the decline in PA from ages 10-11 (17% meeting PA guidelines) to ages 16-20 (10% meeting PA guidelines). A 17-year follow-up longitudinal study of PA was conducted in Finland (N = 7794; 47% male, ages 14 and 31 years) which found that sport participation once per week in females and twice per week in males at age 14 was associated with high levels of PA in adulthood at age 31. This study also suggests that participating in sports which required diversified skills was the most beneficial for future PA in adulthood (Tammelin, Näyhä, Hills, & Järvelin, 2003).

2.3 Fundamental Movement Skills – Overview.

Emerging as an aspect of MC (Barnett, Lai, et al., 2016), FMS can be defined as the basic 'building blocks' of more advanced movement skills (Gallahue et al., 2012). As noted by Logan et al. (2018), the terms 'fundamental movement skills' and 'fundamental motor skills' are often used interchangeably within literature. Despite this synonymity, Gallahue, Ozmun, and Goodway (2012) outline a distinct difference between the terms 'motor'

and ‘movement’, asserting that the term ‘motor’ describes underlying mechanisms of movement (i.e. neuromuscular), whereas ‘movement’ describe the observable act of moving. FMS are generally split into 3 subsets during assessment and observation: locomotor (e.g. running, skipping, vertical & horizontal jumping), object control (e.g. throwing, catching, kicking, dribbling, striking) and stability (e.g. balancing, rock, log roll, back support) (New South Wales Department of Education and Training, 2000; Rudd et al., 2015; Ulrich, 2000; Victoria Department of Education, 1996).

FMS research has received criticism (Almond, 2014; Pot & van Hilvoorde, 2014) , namely that 1) FMS are not all fundamental skills, 2) each FMS only leads to a limited number of skills, 3) skills are learnt by doing rather than being taught and 4) there is little data supporting associations of MC and PA. Barnett et al. (2016) responded to these claims, stating that the named FMS may not be fundamental for everyone, and may indeed be culturally irrelevant in some contexts, however, the authors do argue that FMS are still fundamental parts of many sports. Further to this, Barnett et al. (2016) outlined that youth will benefit from FMS instruction, in a similar manner to being taught to read and write, and point to systematic review evidence of association between FMS and PA, as well as other aspects of health-related fitness such as weight status (Cattuzzo et al., 2016).

2.3.2 Fundamental Movement Skills – Associated Health Benefits

FMS proficiency has been repeatedly associated with the health-related behaviour of PA, with those identified as being more FMS proficient often being identified as more physically active (Cohen et al., 2014; Holfelder & Schott, 2014; Logan, Kipling Webster, Getchell, Pfeiffer, & Robinson, 2015;

Lubans et al., 2010; Williams et al., 2008). Stodden et al. (2014) suggested that developing object control proficiency in childhood may improve health-related fitness in adolescence. In a longitudinal research study, Bryant et al. (2014) found that individuals with higher FMS proficiency were found to be more physically active at a one year follow-up stage.

Lubans et al. (2010) systematic review of the health related benefits of FMS outlined a positive relationship between FMS competency and cardiorespiratory fitness. FMS proficiency has been shown to have an inverse relationship with weight status in youth (Kelly et al., 2018; Lubans et al., 2010). Hume et al. (2008) refuted these findings, however, and found that non-overweight youth only performed better than overweight or obese youth in the run skill (Hume et al., 2008). One five-year longitudinal study (N = 668, 54% boys, ages at testing = 5 & 10 years old) found that obesity preceded a decline in motor proficiency amongst youths (Cheng et al., 2016), indicating that obese youth may be at greater risk of under-developing MC, which may in turn lead to them experiencing the negative spiral of disengagement, as theorised by Stodden et al. (2008). Clearly, the development of FMS is an essential factor in building a strong, healthy lifelong participation in PA, and avoiding potential negative health outcomes.

Cohen et al. (2014) found that object control skills, but not locomotor skills were associated with children's MVPA participation, at lunch breaks and recess. This study also found that children who were more competent in object control and locomotor skills were more active during the after-school period. O'Brien et al. (2016) outline that poor FMS proficiency among Irish adolescents will make it difficult for this age cohort to transition into more

advanced skills, which are required in sport-specific contexts, which may in turn lead to a dearth of PA participation.

Other important considerations lie in youths' perceptions of their FMS abilities. Rogers et al. (2018) (N = 173; 100% girls, mean age = 12.48 ± 0.34 years) found moderate and significant positive associations between actual FMS ability and physical self-perception, perceived sports competence, and to a lesser degree perceived FMS. In a qualitative study, Barnett et al. (2013) purported that the perceptions which adolescents held about their own movement skill abilities impact on their motivation for sport and PA. A recent narrative review of FMS and health-related outcomes conducted by Bremer and Cairney (2018), found limited evidence that the development of proficient fundamental movement skill abilities in young children may positively affect the child's self-beliefs, PA, fitness, body composition, and executive functioning in adolescence. Interestingly, Jaakola et al. (2015) found that FMS mastery may contribute to academic achievement (in Finnish language, mathematics and history) in early adolescent schooling.

2.3.3 Fundamental Movement Skill – Proficiency Levels in Ireland and Abroad

Research into FMS proficiency in Ireland has revealed that Irish youth from childhood through to adolescence display low levels of proficiency across FMS, with particularly poor performances in jumping movements noted (Bolger et al., 2018; Kelly et al., 2018; Lester et al., 2017; O' Brien et al., 2016). Poor levels of FMS proficiency, however, are not restricted solely to Ireland as noted by Bolger et al. (2018). Worldwide research continues to demonstrate that these low levels of FMS proficiency in children and youth are a cross-

cultural issue, evidenced by studies in the United Kingdom (Foweather, 2010), Australia (Hume et al., 2008; Van Beurden et al., 2003) and Singapore (Mukherjee et al., 2017) for example.

The observed poor levels of FMS proficiency in children, and adolescents, are all the more disconcerting, given that a typically developing child has the developmental capacity to be proficient in all FMS by the age of six years (Gallahue et al., 2012). This is particularly pertinent, given the link between FMS proficiency and PA levels later in adolescence (Lubans et al., 2010). Interestingly, a recent cross-cultural study between Belgian and American children (N = 326, ages 4 - 5 years), found that participants performed significantly worse in the TGMD-2, when compared to a US norm group in 1997 and 1998, suggesting a progressive downward trend in FMS ability over time (Brian et al., 2018).

2.3.4 Fundamental Movement Skills Age-Related Differences

Age-related differences in FMS proficiency throughout childhood have been noted in several studies, which show a general trend towards age-related improvements in FMS (Bolger et al., 2018; Kelly et al., 2018). Although there appears to be a general trend towards improved FMS with age, literature suggests that this improvement may plateau, with some research suggesting that FMS can plateau as early as 7 to 8 years old (Kelly, O'Connor, Harrison, & Chéilleachair, 2018; Valentini et al., 2016), while others suggest a later plateau age of 10 years old (Behan et al., 2019).

The 'Mountain of Motor Development' metaphor describes maturation development of motor skills using a mountain as a metaphor for development

(J. E. Clark & Metcalfe, 2002). This metaphor suggests that, like a mountain with its peaks and troughs, development is (moving up) a non-linear process. Across the lifespan, motor development may progress, stagnate, or indeed regress. Some skills may progress at different rates for different individuals and for the individual themselves. The mountain metaphor suggests that individuals may move through these stages of motor development: “Beginning around the third gestational month, these periods are (1) reflexive, (2) preadapted, (3) fundamental patterns, (4) context-specific, (5) skillful, and (6) compensation” (Clark & Metcalfe, 2002, p. 11). The onset of the ‘skillful’ stage is theorised to tend to begin around the age of 11-13, however it may never be reached.

Interestingly, Behan et al. (2019) noted that FMS proficiency improved in primary-level students up to the age of 10 years, after which it began to decline as participants move towards second-level schooling. Lester et al. (2017) found that there appears to be a significant inverse association between and age and FMS proficiency in second-level school participants, with a progressive decline in object control skills noted, as age increased. This may be linked to the reported drop off in PA levels, as youth enter early adolescence (Woods et al., 2018), and suggests that the period of change between primary and post-primary school is a crucial time to focus on the maintenance and development of FMS ability, and PA into adolescence.

2.3.5 Fundamental Movement Skill – Sex Differences

Studies of child and adolescent populations have repeatedly found sex differences in FMS performances, with males excelling in object control related skills, and females generally outperforming males in locomotor skill proficiency

(Breslin et al., 2012; Foweather, 2010; Hardy et al., 2012; Kelly et al., 2018; O' Brien et al., 2016; Okely & Booth, 2004). Female performance in object control skills are repeatedly found to be particularly poor (Bolger et al., 2017; Eather et al., 2018). The sex difference in object control FMS proficiency is disconcerting, given that the association between object control skill proficiency strengthens with PA over time and object control proficient children are more likely to be active adolescents (Barnett et al., 2011, 2009). It is unclear if the availability or prevalence of object control related games is the causal factor behind the relationship of PA and object control proficiency in adolescence or not. However, it is worth noting that in Ireland, the most popular sports/activities amongst post-primary youths are almost all object control related (Woods et al., 2018). This is somewhat consistent with findings from a recent survey of activity popularity in England which found that team sports were the most popular activities in adolescents aged 11 – 16 (Sport England, 2019).

The observed sex-based FMS proficiency differences have been attributed to ecological factors, such as societal reinforcement of object control games for males, more so than females in youth (Hume et al., 2008). Sex-based FMS differences have also been linked to male and female choices in play activities across childhood, with males favouring more aggressive large group play (object control sports are usually competitive large group games such as soccer, rugby etc.), and females more often selecting less directly competitive locomotor based activities (e.g. dance, gymnastics, swimming) (Foweather, 2010; Santer, Griffiths, & Goodall, 2007). Further to this, research has reported that children tend to seek out play partners of the same sex, thus

reinforcing the identified sex-based FMS (Santer et al., 2007). According to the recent Children's Sport Participation and Physical Activity (CSPPA) report in Ireland, females were more likely to participate in individual sports than males (Woods et al., 2018).

Biological factors may also play a role in the observed object control differences in males and females, particularly after puberty (such as sex differences in mid-arm muscle mass and a greater shoulder/hip ratio; Wrotniak et al., 2006; Thomas and French 1985; Malina, 1984). Psychological factors can influence these sex differences in object control skills, as males have shown a greater ability to estimate the vector of a moving ball (McGivern, Adams, Handa, & Pineda, 2012). Interestingly, these object control sex differences were not found by Mukherjee, Lye Ching Ting, and Fong (2017) in a study of Singaporean children, which they attribute to equal sex opportunities in lower primary school curricula for FMS practice.

According to the CSPPA study of 5,397 Irish youths (age 10 – 18 years), boys are more likely to engage in extra-school sport than girls, and team-games were the dominant form of extra-curricular sport being practiced in schools (Woods et al., 2010). The CSPPA study of 2018 (N = 6'651) also found that post primary boys are more likely to engage in extra-school sport than girls with 45% of second-level girls reporting never participating in extra-school sport (Woods et al., 2018). Interestingly, the CSPPA study of 2018 also found that school sports were composed primarily of games related team sports (often object control related) and that males were more likely to participate in school sport than females (males = 70% participation, females = 57% participation).

2.3.6 Fundamental Movement Skills – Socioeconomic Differences

Research into the relationship between SES and FMS proficiency displays mixed results. Okely and Booth (2004), found that although there seemed to be associations between SES and FMS mastery in some skills, the results were not consistent enough to conclude that SES is associated with FMS mastery. A study of 6'917 Australian elementary and high-school students (age range 7-14 years old) reported no consistent association between boy's SES background and low FMS competence. However, the study did find that low SES boys and girls were more likely to display low FMS competency than their high SES peers (Hardy et al., 2012). A study of English children (N = 369, 193 boys, age range 4.3 – 7.2 years), however, reported that those of high and middle SES significantly outperformed those of low SES in total, fine and gross motor skills although this study did not specifically measure FMS (Morley, Till, Ogilvie, & Turner, 2015). Outside of FMS research, there appears to be a dearth of research into SES and another growing area of MC, namely functional movement.

2.4 Functional Movement – Overview

Functional movements are multi-planar, multi-joint, strength, stability and mobility dependent movements, which are foundational actions to many sport-related movements (Abraham et al., 2015). Okada et al. (2011) reported that "functional movement is the ability to produce and maintain a balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency" (p. 252). Similar to FMS, functional movements are an example of actual movement skill competence

in youth, which together can offer a greater understanding of motor development (O'Brien, Duncan, et al., 2018).

Anderson et al. (2015) assert that muscle activity, neuromuscular control, and core stability are generally accepted contributors to functional movement, which suggests that functional movement can be included under the umbrella term of MC, according to Utesch (2019), as these primary movements involve motor control. Silva et al. (2019) examined the associations between MC and functional movement, reporting that functional movement was associated with the MC stability construct only, and that performance in the trunk stability push-up was associated with better performance in all areas of MC. A similar result was found by Kramer et al. (2019) who asserted that the FMS™ and the Y-Balance Test™ may evaluate similar underlying constructs, specifically dynamic balance and lower extremity power.

Functional movements also fit under the Hulteen et al. (2018) definition of 'foundational movement skills', which broadened the scope of traditional FMS to include more movements that contribute towards lifelong PA, and positive health trajectories, such as 'resistance training movements' (i.e. squat, push-up). Interestingly, Duncan et al. (2013) speculated that functional limitations may cause less PA, a gain of fat mass, and a consequent lack of fundamental movement pattern development which is similar to the process of positive and negative spirals of engagement in PA described in Stodden et al. (2008) developmental model of MC.

2.4.1 Functional Movement Screen™

The Functional Movement Screen™ (FMS™) was developed as a pre-participation screening tool to evaluate joint mobility and flexibility, and to identify deficiencies from seven upper and lower body movements (i.e. a strategy for reducing injury risks in subsequent PA; Abraham et al., 2015). The tool has grown in popularity amongst the sporting community (Fox, O'Malley, & Blake, 2014). The FMS™ determines if the participant possesses the essential movements required to participate in sporting activities, with a decreased risk of injury (Cook et al., 2006b).

The functional movements identified in the FMS™ are: active straight leg raise, deep squat, hurdle step, in-line lunge, rotary stability, shoulder mobility and trunk stability push-up (Cook et al., 1998, 2006b, 2006a). These identified movements are assessed via a battery of movement performances in which participants are verbally instructed to complete each of the seven specified movements in accordance with the specified criteria from the FMS™ handbook (Cook, 2015). Participants are given a score from zero to three for their specific execution of the movement, with a score of zero indicating pain in the attempt of the movement, a score of one indicating an inability to complete the movement (termed dysfunctional movement by Coker (2018)), a score of two indicating an ability to complete the movement with some compensations, and a score of three indicating a correct performance of the movement (Cook, 2015). The participant's total composite score across the seven identified movements within the FMS™ are then calculated out of a maximal composite score of 21.

The FMS™ has been shown to be reliable in terms of inter-rater reliability in individual and test-retest scenarios (Minick et al., 2010; Schneiders, Davidsson, Hörman, & Sullivan, 2011; Teyhen et al., 2012). Importantly, a systematic review and meta-analysis concluded that significant concerns remained about the validity of the FMS™ (Bonazza, Smuin, Onks, Silvis, & Dhawan, 2017) .

2.4.2 Functional Movement Screening and Injury Risk Detection

Kiesel et al. (2007) (N = 46) and Chorba et al. (2010), (N = 38, mean age = 19.24 ± 1.20 years) in populations of professional American Football Players and female collegiate athletes respectively, suggested that an overall FMS™ composite score of below 14 was predictive of injury in the athletic season. As a result, the composite score of 14 has become a commonly reported threshold found in FMS™ research in association with injury risk. Conversely, recent research (N = 132, 100% male, age range 18 – 25 years) found no significant correlation between the FMS™ composite score and likelihood of injury in a military population, however, the authors did find that individuals who scored a 1 (i.e. dysfunctional movement performance) on any test were 1.3 times more likely to become injured than those who did not score a 1 (Everard, Lyons, & Harrison, 2018).

Following their exploratory factor analysis of the FMS™, Li et al. (2015) concluded that the individual task scores were more important to consider than the composite score when interpreting FMS™ results. This was also found by the Mokha et al. (2016) study with collegiate athletes (N = 84, Male = 20, mean age = 20.4 ± 1.3 years; female = 64, mean age = 19.1 ± 1.2 years) who found

no association between a composite score ≤ 14, however, an asymmetrical score or score of 1 in any movement put the individual at a 2.73 times greater risk of musculoskeletal injury.

Interestingly, it has been found that knowledge of the grading criteria of the FMS™ has resulted in participants' improvement within actual movement screening proficiency (Frost, Beach, & McGill, 2015). This finding has cast some doubt on whether the FMS™ actually assesses functional movement capacity, as a true indicator of functional movement should not be impacted through knowledge alone. The FMS™ has also received criticism for showing little evidence as a means of assessing movement when related to PA, or sport participation (Parchmann & McBride, 2011). Further to this, a systematic review of FMS™ literature has found that it shows low injury predictive validity (Dorrel, Long, Shaffer, & Myer, 2015). A study amongst youth athletes (N = 144, 96 girls, age range = 8 – 18 years, mean age = 14.1 ± 2.3 years) suggests that the FMS™ demonstrates poor internal consistency, and movement tasks as well as the 4-point scoring system should be altered to ensure that it is a fit measurement of youth movement competence (Wright & Chesterton, 2019). Research of the FMS™ is often carried out on adult military/service (Bock, Stierli, Hinton, & Orr, 2016; Everard et al., 2018), or athletic populations (Anderson et al., 2015; Chalmers et al., 2017; Dinc, Kilinc, Bulat, Erten, & Bayraktar, 2017; Fox et al., 2014; Li et al., 2015; Mokha et al., 2016), and little research has been carried out on general adolescent populations.

2.4.3 Functional Movement Proficiency – Ireland and Abroad

Normative values for general adolescent populations has been established in a comprehensive study (N = 1'005, age range 10 – 17 years) of

Indian adolescents, reporting a mean composite score of 14.59 (CI 14.43 – 14.74) using the FMS™ assessment tool (Abraham et al., 2015). It is important to note, however, that an inclusion criterion for this study was that participants met regular PA guidelines, which may have skewed the results. In comparison, research into the functional movement proficiency of adolescents in Ireland (N = 219, mean age = 14.45 ± 0.96 years) reported a similar mean score of 14.05 ± 2.48 (O'Brien, Duncan, et al., 2018). Duncan et al. (2013; N = 90, 38 boys, age range = 7 to 10 years) reported a mean composite FMS™ score of 13.2 ± 3.0 in a study conducted in the United Kingdom, Britain. While these figures were carried out in general youth populations, in the interest of comparison, a New Zealand based study (N = 209, 101 Males, age range 18- to 40- years old) of active young adults reported a mean score of 15.7 (CI = 15.4 – 15.9), which suggests that active populations will score higher in their functional movement, when using the FMS™ assessment tool. One other study in Ireland (N = 62, 100% male, mean age = 22.15 ± 3.02 years) has reported normative FMS™ scores, however, this was in a sample of young adult elite and sub-elite adult Gaelic football and hurling players, which reported a mean composite score of 15.56 ± 1.46.

2.4.4 Functional Movement – Age and Sex Differences

2.4.3.1 Age-Related Differences

A recent study of Spanish primary school children by Garcia-Pinillos et al. (2019; N = 172, 83 girls, age range = 6 – 11 years) revealed that age was a moderate determinant of FMS™ scores. Age-related, or maturational effects on functional movement have also been reported amongst youth athletic populations in functional movements, which rely on stability (in-line lunge,

hurdle step, rotary stability, and trunk stability push-up; Wright & Chesterton, 2019). Maturational effects were also found in a small study (N = 30, age groups: under 11 years, under 13 years, and under 16 years) of soccer players from a professional club in England, with FMS™ composite mean scores by age group showing a positive trend from under 11 = 12.0 ±1.5, to under 13 = 12.5 ± 3.0, and finally a large jump in mean composite score in under 16's = 16.0 ± 2.0. Further to this, another much larger study of English elite adolescent soccer players (N = 1'163, age range = 8 to 18 years old) reported that the ability to achieve a satisfactory score (noted as 14) in the FMS™ increased considerably throughout adolescence. This seems to suggest that post-pubescent adolescents have higher FMS™ scores when compared to pre-pubescent adolescents, which is in line with results from an American study by Paszkewics et al. (2013; N = 66, 29 girls, age range 8 to 14 years old). Conversely, Abraham et al. (2015) showed that there was no significant association between age and FMS™ mean composite score. Interestingly, an Irish study (N = 181, mean age = 14.42 ± 0.98 years) of adolescents found similar findings to that of Abraham et al. (2015), specifically that performances in the in-line lunge only declined with age (Lester et al., 2017). The lack of strong associations between age and FMS™ mean composite scores may indeed support the non-linear development of children maturational theory (Garcia-Pinillos et al., 2019; Malina et al., 2012)

2.4.3.2 Sex Differences

Sex differences have been demonstrated in FMS™ based studies, which show that males outperform females in a variety of functional movements, including the in line lunge, active straight leg raise, trunk stability

push-up and the rotary stability tests (Abraham et al., 2015; Anderson et al., 2015). Conflicting evidence, however, has been found in an Irish sample by O'Brien et al. (2018), who reported that females significantly outperformed males in overall FMS™ composite score. Other studies have reported no significant differences between the sexes, with regards to total FMS™ performance (Duncan et al., 2013; Garcia-Pinillos et al., 2019; Paszkewicz et al., 2013), however, these studies were primarily carried out on younger children. The most commonly found difference between males and females in FMS™ performance appears to be related to male dominance in the trunk stability push-up, which has been found across several studies, and has been attributed to potentially greater upper body strength of males in comparison to females (Duncan et al., 2013; O'Brien, Duncan, et al., 2018; Schneiders et al., 2011; Wright & Chesterton, 2019). The active straight leg raise have also been found to exhibit sex-based differences in repeated functional movement performances (Duncan et al., 2013; O'Brien, Duncan, et al., 2018; Schneiders et al., 2011). Females tend to outperform males in this specific functional movement, which has been attributed to greater female flexibility (Schneiders et al., 2011). O'Brien et al. (2018) and Schneiders et al. (2011) also found female superiority in the shoulder mobility movement, which suggests that certain functional movements display sex-related differences (Karuc & Mišigoj-Duraković, 2019).

2.4.5 Functional Movement – Associated Health Benefits

In a review of literature pertaining to functional movement in adolescents, Karuc et al. (2019) concluded that it is important to highlight the health benefits of optimal functional movement in youths, and the

consequences of dysfunctional movement on the locomotor domain. Duncan and Stanley. (2012) found a positive association between functional movement performance and PA, and a negative association between functional movement and weight status (as measured using the FMS™). A study of 56 children (33 girls, aged 8- to 12- years old) determined that all fatness indicators (body mass index, body fat percentage and fat mass index), except waist circumference, were negatively associated with functional movement scores, regardless of participants levels of cardiorespiratory fitness (Molina-Garcia et al., 2019). Furthermore, the authors of this study found that the components of physical fitness (i.e. cardiorespiratory fitness, lower limbs muscle strength and speed agility) also had positive associations with FMS™ scores (Molina-Garcia et al., 2019). Under the broader understanding of MC (Hulteen et al., 2018), functional movement (as a goal-directed human movement) represents an aspect of physical competence which, when developed, can improve individual's ability to engage in PA. This situates functional movement as an important element for consideration in the growing movement around developing individual's physical literacy (PL) towards lifetime participation in PA.

2.5 Physical Literacy Overview

PL is a term coined by Whitehead (2001), which detailed a holistic view of an individual's physicality based on the philosophical principle of monism. The monist perspective views the mind and body as one being, as opposed to the dualist perspective of body and mind separation. PL was recently defined as part of a national consensus statement for all Canadian organisations involved in the area of PL as the "motivation, confidence, physical

competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" (Tremblay, Costas-Bradstreet, et al., 2018, p.16). In an interview, Whitehead described the fundamental goal of PL to be lifelong participation (Spengler, 2015).

PL encompasses four separate elements; the affective domain (motivation and confidence); the physical domain (physical motor abilities); the cognitive domain (knowledge and understanding), and the behavioural domain (lifetime engagement; Robinson & Randall, 2017). In Spengler's (2015) global scan of PL, they identify ten countries in which PL is recognised in policy or programmes; Canada, Wales, England, Scotland, Northern Ireland, Australia, New Zealand, Netherlands, United States of America, and Venezuela. Interestingly, they identify that of these countries, all except for Venezuela rank in the top 21 wealthiest countries in the world.

Despite its importance in policy planning documents in Northern Ireland for the past decade (2009 – 2019; Department of Culture Arts and Leisure & Sport Northern Ireland, 2009), PL is still in its infancy in the Republic of Ireland. While mentioned briefly in the framework for the Lifelong Involvement in Sport and Physical Activity (LISPA; MacPhail, Lyons, Quinn, Hughes, & Keane, 2010), there is an absence of empirical evidence investigating the concept of PL and no explicit mention of PL in any PE curricular documents (National Council for Curriculum and Assessment, 2018; National Council for Curriculum and Assessment; Department of Education and Science, 1999; National Council for Curriculum and Assessment; & Department of Education and Skills, 2016; National Council for Curriculum and Assessment; Department of Education and Skills, 2017). While there exists a lack of empirical research on

the concept of PL in Ireland, leading researchers in the field of adolescent activity promotion have opened the dialog on PL in Ireland recently (Belton, Issartel, McGrane, Powell, & O'Brien, 2019; O' Brien, Belton, & Issartel, 2015a) citing the Y-PATH intervention as a possible vehicle towards the adoption of PL in Ireland.

2.5.1 Physical Literacy Assessment

According to Spengler et al. (2015), Canada, Wales and England are leading the way in regard to PL, with each country delivering PL programmes which promote and assess the cognitive, affective and physical components of PL, through their sport and education systems. PL, however, has been shown to be a difficult concept to measure/assess due to current research in the area utilising incompatible methodologies (Edwards et al., 2018). A comprehensive assessment tool pertaining to PL has been developed in Canada called the Canadian Assessment of Physical Literacy (CAPL). The CAPL was designed based on 4 conceptual domains (Motivation & Confidence, Physical Competence, and Knowledge & Understanding, and Daily Behaviour), encompassing PL. Each domain contains tests designed to assess youth's PL (Healthy Active Living and Obesity Research Group, 2013). This CAPL measurement tool has been found to be an effective measure of PL in the 8 to 12 year old age bracket (Longmuir et al., 2015), and is recommended as a means of PL evaluation (Tremblay & Lloyd, 2010). The second iteration of the CAPL, the CAPL-2 has been released recently, which is a streamlined version of the originally produced CAPL (Longmuir et al., 2018). While both assessments are based on the same four domains (Physical Competence, Daily Behaviour, Knowledge and Understanding, and Motivation

and Confidence), they differ in terms of the assessments which take place for each subdomain. Figure 2.3 below highlights the assessment differences between the CAPL and the CAPL-2 for each of these subdomains.

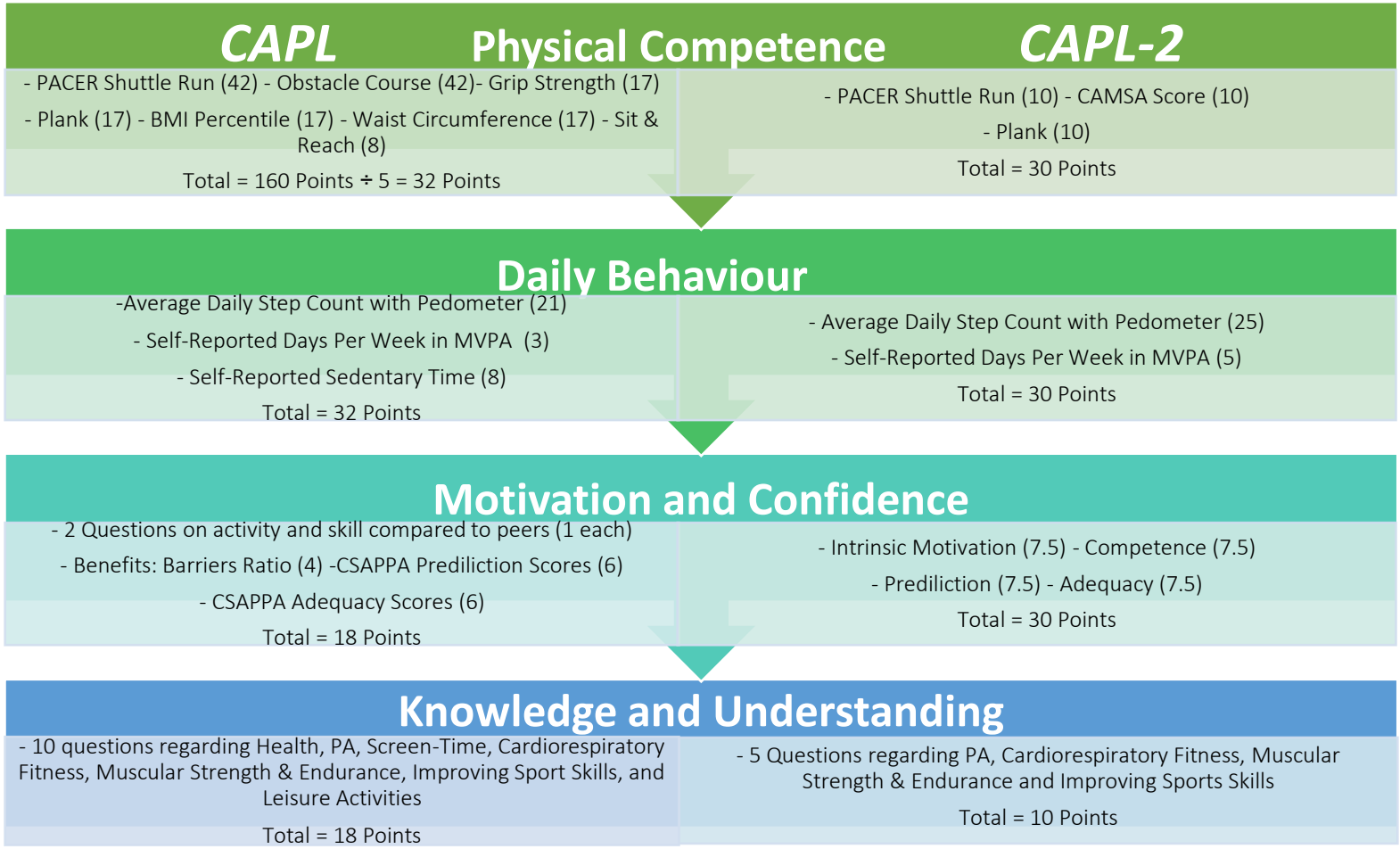

Figure 2.3.: Comparison of the CAPL and CAPL-2 assessment measures of the four identified subdomains. Note. Figures in parentheses (x) indicates points allocation for the measure. Based on CAPL (Healthy Active Living and Obesity Research Group, 2013) *and CAPL-2 guidelines* (Healthy Active Living and Obesity Research Group, 2017). Figure 2.3 Notes Continued: The CAPL Motivation and Confidence section specifies the utilisation of the "What's Most Like Me" Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA) questionnaire (Hay, 1992). PACER is an abbreviation of Progressive Aerobic Cardiovascular Endurance Run. CAMSA is an abbreviation of the Canadian Agility and Movement Skill Assessment

The second iteration of the CAPL is more practical for examiners and participants, as the tool only consists of three physical competence measurements, two daily behaviour protocols and a 22 response item questionnaire (Longmuir et al., 2018). As specified in Figure 2.3, the CAPL-2 still consists of four sections, however, each section has a simplified points allocation, which contributes to the overall score out of 100 points as follows: Physical Competence (30 points); Daily Behaviour (30 points); Motivation and Confidence (30 points); and Knowledge and Understanding (10 points). The Physical Competence section involves children completing the Plank exercise (10 points), the PACER Shuttle Run Test (10 points), and the CAMSA FMS performance (10 points; Longmuir et al., 2018).

The simplified CAPL-2 scoring system categorises individuals based on their percentile score: 1) beginning 2) progressing 3) achieving 4) excelling (Healthy Active Living and Obesity Research Group, 2017). The first large scale study of PL (N = 10,034; 50.1% girls, age range 8 to 12 years) using the CAPL has established baseline Canadian PL scores of 63.1 ± 13.0 for boys and 62.2 ± 11.3 for girls (out of 100; Tremblay, Longmuir, et al., 2018). A study of PL amongst Greek children (N = 715; mean age = 10.2, SD 1.3 years) reported similar PL levels amongst their sample, and both samples would be categorised to be in the 'progressing' category according to the CAPL-2 scoring guidelines (Kaioglou, Dania, & Venetsanou, 2020).

2.5.2 Physical Literacy – In Practice

PL is viewed as a new vista through which PE can be delivered, specifically to give lifelong benefits to learners through creating individuals who are intelligent movers, and are holistically prepared for lifelong activity (A.

Chen, 2015). A recent publication outlined the practical implications of PL for teachers and physical educators, by identifying seven key principles of the concept: (1) Focus on the Individual; (2) Promoting Motivation; (3) Self-Confidence; (4) Physical Competence; (5) Developing Knowledge and Understanding; (6) Devolving Responsibility; (7) Using Feedback/Charting Progress as a Motivational Tool (Durden-Myers, Green, & Whitehead, 2018). As such, in enacting PL, these key principles should underpin and inform a teacher's planning for young people's PA engagement.

A problematic issue identified within PL is that adequate physical movement assessments do not exist to measure motor skill abilities in general populations (Giblin, Collins, & Button, 2014). According to Roetert and MacDonald (2015), incorporating PL in PE will require teaching a broader spectrum of activities, which deviates from the traditional practice of team games to minimise social comparison, and develop individuals toward lifelong PA. Interestingly, they also specify that early grade PE teaching should focus on FMS development.

2.5.3 Physical Literacy, Fundamental Movement Skills & Motor Competence

Whitehead, (2001) was clear in asserting that although movement capacity is a vital part of PL, it can never constitute the whole definition. Durden-Myers et al. (2018) described the term 'movement patterns' as the building blocks of effective PA and note some 'foundation movement patterns' under the headings: balance, locomotion, flight, manipulation, and projection. Durden-Myers et al. (2018) suggested that these foundation movement patterns are typical in children in their early years and contains all movements of which humans are capable. This description resembles the Gallahue,

Ozmun and Goodway (2012) definition of FMS, however, Durden-Myers et al. (2018) explicitly stated that the two constructs are non-equivocal as FMS are relevant to game-play contexts and are not fundamental to general movement and FMS are presented as closed skills to be replicated. The relationship between PL and FMS are problematised in an article by Almond (2013), who suggested that the issue is that skills are by definition going to be associated with games. Associating PL and FMS too closely may negatively impact the application of PL as only game-related movements (e.g. kick and catch) may be developed at the expense of non-game-related skills which individuals need to be active throughout the lifespan.

A recent meta-analysis of 32 PL articles found that research across the field of PL researchers are utilising incompatible methodologies, based on inconsistent interpretations of PL, and many studies measure individual elements of the PL concept, rather than PL as a holistic concept (Edwards et al., 2018). This highlights that while MC is an important aspect of PL, this domain is only a part of the overall concept of PL. Nevertheless, MC remains an important aspect of PL to be examined and developed, given its importance in children's development (O'Brien, Duncan, et al., 2018), most notably in the physical domain of PL. Outside of the physical competence element of PL, a key area of PL is how individuals view themselves and their motivation/confidence to partake in activity, this relates to the research of Perceived Motor Competence (PMC).

2.6 Perceived Motor Competence – Overview

PMC emerged from the work of Harter (1982), under the general area of perceived competence in her 'Perceived Competence Scale for Children'

paper. Harter (1982) outlines that perceived ‘physical competence’ is a subscale in children’s overall perceptions of their competence, which was related to their perceptions of their ability to do well in sports and outdoor games, and to take part in the activities. Perceived competence is known by other names (e.g. perceived physical ability) and is considered a central determinant of behaviour in several social cognitive theories (Babic et al., 2014).

Estevan et al. (2018) outlined that PMC relates to how well one believes that they can perform a particular skill in a given context, rather than how they can perform the skill generally. As such, the authors are claiming that PMC is not about evaluating a child’s ability to throw in general, but rather in a specific context related to the motor skill performance. Estevan et al. (2018) continued to suggest that, in the context of young children, PMC could be interpreted as the perception of ability to carry out a specific FMS, such as the kick. As part of this rationale, PMC relates specifically to motor performance, aligned to the domain of MC, as described previously. There is, however, some differentiation in the terms used to denote perceptions of their own ability, such as “self-confidence”, “self-efficacy”, “perceived ability” and “perceived competence” (Feltz, 1988).

PMC is the most generally used term in this field, however, some Irish research has used the term Perceived Self-Confidence, based on the Physical Self-Confidence Scale (McGrane, Belton, Powell, Woods, & Issartel, 2016) to determine youth’s perceptions of their own abilities. O’Brien et al. (2018), however, outline that this perceived self-confidence is also measured at the skill-specific level, similar to the PMC rationale proposed by Estevan et al.

(2018). In congruence with the Irish research, Barnett et al. (2018) included perceived motor confidence in their analysis of cross-cultural perceptions of movement competence, and aligned the terms confidence and competence, as they both inform the field of motor perception, suggesting an overlap in these terms.

It is important to consider youths' perceptions of their abilities, as research suggests that fostering children's perceptions of their own motor competence may improve their motivation to take part in sports (Bardid et al., 2016). Interestingly, Barnett et al. (2008) discovered that perceived sports competence mediated the relationship between childhood skill proficiency, PA and physical fitness in adolescence, highlighting the importance of developing motor skills in youth to build self-perceptions which, in turn, can increase PA and physical fitness levels. It is, however, also important to note that children's perceptions of their own MC may not be very accurate. Estevan et al. (2018; N = 139, 48.2% girls, age range = 6 to 11 years) discovered that children showed limited ability to rate their own MC abilities, whereas PE teachers were found to be a more valid reporting mechanism on children's MC, even better than the child's parents.

2.6.1 Perceived Motor Competence Assessment

There are several instruments being used currently to assess youth perceptions of MC across different countries and cultures. As elucidated by Barnett and Goodway (2018), it is important that the assessment instrument is suitable for each cultural context. Amongst young children, the Australian pictorial scale of Perceived Movement Skill Competence in Young Children (PMSC; Barnett, Ridgers, Zask, & Salmon, 2015; Barnett, Vazou, et al., 2016)

has been validated for use amongst young children to examine their perceptions of movement skill competence.

The PMSC scale consists of twelve TGMD-2 FMS (six locomotor, six object control; Ulrich, 2000) and six Active Play activities (bike, board paddle, climb, skate/blade, scooter, and swim; Barnett, Vazou, et al., 2016). Children are asked to select one of two cartoon images; one image represents a competent performance of a specific FMS/Active Play activity, and the other shows an incompetent performance. If the child has completed the activity before, they then select which image is most like them, if not, they are given an additional demonstration of the skill/activity, and they answer hypothetically. If the child selects the competent image, they are asked to rate their performance by choosing from 'really good at…' (score of four) or 'pretty good at…' (score of three), however, if a child selects that they are most like the incompetent example, they can select from 'not that good at…' (score of one) or 'sort of good at…' (Barnett, Vazou, et al., 2016; Venetsanou, Kossyva, Valentini, Afthentopoulou, & Barnett, 2018). Outside of its native context, the PMSC has been validated cross-culturally in Brazil (Valentini et al., 2018), Greece (Venetsanou et al., 2018), and Spain (Estevan, Molina-García, Castillo, et al., 2018).

An assessment instrument called the Physical Self-Confidence Scale (PSC) has been created and successfully tested for reliability and validity in Ireland for use amongst adolescents to measure their perceptions of their FMS abilities (McGrane et al., 2016). The measure of perceived confidence is slightly different to the measure of perceived competence, yet they are both relevant in the field of motor perception (Barnett & Goodway, 2018). The PSC

scale utilises fifteen questions in which participants rate their perceived confidence to perform the specified skill. Twelve of the selected FMS, are taken from the TGMD-2 (Ulrich, 2000) instrument, with the remaining three FMS taken from the original TGMD and the Victoria Fundamental Motor Skills manual (Ulrich, 1985; Victoria Department of Education, 1996). Participants must rate their confidence for the particular skill on a 1-10 Likert scale, with '1' being not confident at all and '10' being very confident. The PSC has been used often in the study of adolescent motor perception in Ireland (Farmer et al., 2017; McGrane, Belton, Powell, & Issartel, 2017; O'Brien, Duncan, et al., 2018).

2.6.2 Perceived Motor Competence and Physical Activity

Evidence from a systematic review and meta-analysis suggests that perceived competence is significantly associated with PA in young people, and strategies which enhance youth's physical self-perceptions can help to promote PA levels (Babic et al., 2014). Qualitative research in adolescents have identified that motivation for participation in sport and PA is impacted by individual's perceptions of their own movement skill abilities (Barnett et al., 2013). Further to this, research has demonstrated that youth with lower PMC are less autonomously motivated to take part in sports (Bardid et al., 2016).

Stodden's developmental model (2008) cites PMC as a crucial intervening factor, which affects the development of either positive cycles of engagement in PA, or negative cycles of disengagement with PA. Notably, a study of 215 adolescents (66% boys, mean age 13.64 ± 0.58 years) determined that amongst those with low actual MC, those with high PMC (over-estimators) were significantly more physically active than those of a

similar actual MC level, but who were accurate in their perception of their ability level (De Meester et al., 2016). While Khodaverdi et al. (2013) have found that actual MC has been demonstrated to have more influence on PA levels in children than PMC, they advise the inclusion of both variables in any intervention programmes for children and youth.

2.6.3 Perceived and Actual Motor Competence

The developmental theory of Stodden et al. (2008) postulates that less skilled children will have lower perceptions of their abilities, and will perceive tasks as more difficult, whereas higher skilled children will perceive their abilities to be better, and will view tasks as less challenging and engage in mastery attempts more often, with the authors believing that this relationship will lead to more alignment between the PMC and actual MC constructs.

There are mixed findings regarding the alignment of PMC and actual MC in the literature (Clark, Moran, Drury, Venetsanou, & Fernandes, 2018; O'Brien, Duncan, et al., 2018). For example, De Meester et al. (2016) found moderate correlations between actual and perceived MC amongst a sample of Flemish adolescents. Robinson (2011; N = 119, mean age = 4.00 SD 0.055 years) also found significant moderate correlations between FMS and perceived physical competence in a sample of young children. However, Lopes et al. (2017; N = 200; 55% girls, age range 5 to 9 years) found weak evidence of a relationship between actual and perceived motor competence, rather, they found high levels of PMC across sex and age groupings. In a recent study of young children (N = 603; 301 girls, aged 6 to 7 years). Morano et al. (2020) found weak associations between the children's actual and

perceived competence suggesting that the children were not cognitively developed enough to accurately estimate their own MC.

Alignment of PMC and actual MC seems to be an inconclusive phenomenon, as evidenced by Bardid et al. (2016; N = 161; 40% boys, mean age = 8.82 ± 0.66 years), which found that approximately half of the children displayed convergent PMC and actual MC (e.g. high actual ability and high perceptions of their ability), whereas the other half displayed divergent or unaligned PMC and actual MC.

2.6.4 Perceived Motor Competence: Age and Sex Differences

2.6.4.1 Age

Babic et al. (2014) noted that age was a significant moderator of the association between perceived competence and PA, reporting that early adolescents displayed the strongest association between both variables. This was attributed to young children not possessing the cognitive skill to assess their own motor skills with accuracy. The enhanced ability to perceive one's motor-skill ability was theorised by Stodden et al. (2008), who suggested that by middle childhood, individuals should possess the cognitive capacity to assess their own abilities more accurately. Given the mixed results regarding the alignment of actual MC and PMC (Clark et al., 2018; De Meester et al., 2016; O'Brien et al., 2018; Robinson, 2011), it is unclear whether Stodden and colleagues' (2008) theory (in relation to PMC) is accurate or not.

2.6.4.2 Sex Differences

In the Irish context, significant sex differences in motor self-perception are also evident, as McGrane et al. (2017) identified that amongst 395 Irish adolescents (girls = 196, aged 13.78 ± 1.20 years), males overrated their own

motor ability, when compared to females, who reported levels of confidence in their abilities that were more in line with their actual motor ability levels. This finding appears consistent in Irish literature, as O'Brien et al. (2018; N = 219, 120 boys, mean age 14.45 ± 0.96 years) also reported that adolescent males had higher perceptions of their own abilities in FMS, as well as functional movements, when compared to adolescent females. Outside of Ireland, research in the area of motor self-perception have also consistently found that amongst youth, males rate their own MC higher than females (Clark et al., 2018; Robinson, 2011).

2.7 Motor Competence and PA Interventions - Overview

Many research studies which report on youth MC (including both FMS and FMS™) and PA suggest the need for interventions to take place to ameliorate the observed low levels of MC proficiency and PA in youth (Barnett et al., 2009; Belton et al., 2014; Kelly et al., 2018; Lester et al., 2017; McGrane et al., 2017; O'Brien, Issartel, et al., 2018; Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007). De Meester et al. (2009), conducted a systematic review of European PA interventions, and found that school-based interventions were the most popular, however, these environments generally produced short-term improvements in PA. Findings from this research (F. De Meester et al., 2009) study also suggested that the inclusion of parents appeared to enhance school-based interventions; and that interventions which attempted to target more than one health behaviour were less effective in developing PA levels.

Timperio et al. (2004), reviewed strategies to improve PA in youths and suggested that it is important to consider how best to intervene effectively in the adolescent population, as evidence-based interventions must consider the generalisability of their evidence across the population. For example, different considerations for children from lower SES backgrounds. Interestingly, this review also found no evidence of interventions producing sustained increases in youth PA.

Lai and colleagues' (2014), review of school-based PA and FMS interventions, highlighted that theoretically-based interventions of longer than one year in duration are effective in improving PA. Lai and colleagues (2014) also cautiously note that FMS may be sustainably improved through interventions, however, more FMS studies with long-term follow ups are required. Duncan and Stanley (2012), in discussing the FMS™, highlighted an important consideration when carrying out a pre to post-intervention comparison, which is that there may exist a potential practice effect, which influences performance.

2.7.2 Fundamental Movement Skills Interventions

Morgan and colleagues' (2013) systematic review of 19 FMS interventions determined that school-based PE interventions, with developmentally appropriate activities, can improve FMS abilities, however, they specify that the intervention should be delivered by PE specialist teachers, or alternatively, highly-trained classroom teachers. Morgan and colleagues' (2013) review also found a dearth of long-term follow-ups in these trials. A recent teacher-led, PE-based FMS intervention called the A+ FMS has demonstrated with empirical evidence, using a Randomised Controlled Trial

(RCT) research design, that FMS can be improved in a large sample of youth (N = 282; mean age = 8.4 ± 0.56 years; Chan et al., 2019). The A+ FMS intervention encouraged teachers to use the TGMD-3 assessment as a pedagogical tool to evaluate students' abilities, and to use this information to plan their lessons around developing FMS. This intervention, however, did encourage teachers to openly share the TGMD-3 assessment criteria with their students, which may have caused a 'teaching to the test' scenario.

Another teacher-led, PE-based FMS intervention study of Australian adolescent females (N = 190; 103 control, mean age = 12.4 ± 0.3 years) by Lander et al. (2017) highlighted that by adequately training teachers in student-centred pedagogy, FMS can be significantly improved through a 12-week intervention. Bryant et al. (2016; N = 165; 83 control, mean age 8.3 ± 0.4 years) found that one FMS focussed PE lesson per week for six weeks was sufficient to improve the children's FMS mastery, PA and physical self-perception. Barnett et al. (2009) suggested that community and school-based FMS interventions are a strategy to promote long-term PA, however, they also recommend a particular focus on object-related skills, given their findings that children who were proficient in object control skills became more active adolescents. Lester et al. (2017) have developed an interesting and novel take on intervention development, suggesting that the development of a 'movement-oriented' intervention towards improving both FMS and functional movement could be prudent.

2.7.3 Functional Movement Interventions

In their review of literature pertaining to functional movement in adolescents, Karuc et al. (2019) outlined the importance of practitioners

administering interventions which develop functional movement, alongside PA and weight management in youth, to defend against injury and suboptimal movement, which may develop throughout the lifespan. Coker's (2018) recent PE-based intervention in early adolescents (N = 120, 54 boys, mean age 13.18 years, SD 0.39 years) found that males in the functional movement intervention group showed a significant increase in their functional movement composite scores, when compared to their male counterparts in the control group (Coker, 2018). These findings were a result of a six-week intervention programme, entailing specialised warm-up routines, which focussed on ankle mobility, pelvic stability, inactive and/or weak gluteal muscles, abductors, and adductors, when measured against a traditional dynamic warm-up routine. Interestingly, the intervention demonstrated noted success in ameliorating dysfunctional movement performance (i.e. scores of 1).

Kiesel et al. (2011) also demonstrated that functional movement scores could be improved utilising a seven-week off-season intervention, however, this was conducted with a sample of 62 professional American football players. Conversely, Frost et al. (2012) found no significant functional movement composite score improvements in either of two intervention groups, or their control group, following a 12-week exercise programme amongst a population of firefighters. Wright et al. (2015) conducted a small scale (N = 22; mean age = 13.4 ± 0.9 years, age range 11.8 – 15.2 years) 4-week 'fundamental movement' intervention (consisting of exercises such as: lunging, squatting landing, push-ups, plank etc.) on students from a gifted and talented programme, and again reported little impact on total functional movement scores.

2.8 Literature Review Summary

Literature pertaining to MC highlighted poor actual MC levels in youths across both FMS and FMS™. PA in youths also seems to be low and declining. MC and PA to both be important factors contributing to health and share a reciprocal relationship. Research on interventions across MC and PA highlight the need for interventions to be evidence-based, focussed, and appropriate to the given population. Teacher-led, PE-based interventions demonstrate some success, and it is important to follow-up on the intervention's longer-term impact. Interventions' pedagogical and theoretical basis are also important to consider. Literature on PL and PMC highlight the need to consider factors outside of actual MC when aiming to develop the learner by considering their motivation and cognition.

Chapter III (Study I)

Title: An Investigation of Fundamental Movement Skills and Functional Movement in Irish Adolescents: Proficiency Levels and Relatedness

3.1 Abstract

Background: Evidence suggests that Irish youth display poor actual motor competence across fundamental and functional movement performance. Recent research is shifting views of motor competence to encompass a more holistic view of movement.

Purpose: The purpose of this study was to gather and investigate actual motor competence data amongst Irish adolescents, if sex-based differences exist, and to evaluate if associations exist between fundamental movement skills and functional movement constructs.

Methods: Study included 373 adolescents (178 girls; mean age: 14.38 ± 0.86 years) from six Irish post-primary schools. Actual motor competence testing included 10 fundamental movement skills, and seven functional movements.

Results: Overall levels of actual motor competence in both fundamental (mean composite score = 64.90 ± 6.20 out of a possible 84) and functional movement (mean composite score = 12.01 ± 1.97 out of a possible 21) were low and identified levels of dysfunctional movement were high. Independent samples t-tests revealed significant sex-based differences in both fundamental and functional movement constructs. A moderate association ($r = 0.375$, $p \leq .001$, $R^2 = 0.141$) was found between fundamental and functional movement overall composite scores.

Discussion: Results highlight the need for a movement-oriented intervention to target movement deficiencies in youths. The moderate association between fundamental

and functional movement warrants further research into the interrelationship of these movement constructs and into their joint inclusion in a movement-oriented intervention.

Keywords: Motor Competence; Motor Proficiency; Functional Movement Screen™; Youth; Fundamental Movement Skills; Sex Differences

3.2 Introduction

The ability to move well is theorised to be an integral part of youth development, and an essential factor in determining positive health behaviours for the individual as they mature (Stodden et al., 2008). Motor competence (MC) describes the ability that underlies the performance of a wide variety of gross and fine motor skills (Utesch et al., 2016). Logan et al. (2018) described fundamental movement skills (FMS) as a popular term in reference to MC, and argue that FMS can also be called 'fundamental motor skills'. According to Gallahue, Ozmun and Goodway (2012), motor skills are the same as movement skills, with the term 'motor' describing the underlying factors affecting movement, and 'movement' describing the observable act of moving.

High levels of MC have been associated with increased levels of physical activity (PA), and lower levels of sedentary behaviour (Barnett et al., 2009; Wrotniak et al., 2006). MC has also been shown to be closely related to health-related physical fitness in childhood, and early adolescence (Luz et al., 2017). Gallahue, Ozmun and Goodway (2012) argued that the development of MC in a wide variety of movement skills can help bridge a successful transition towards more specialised movements. It is, therefore, important to consider a broad range of movement skills when attempting to understand MC in youth (Hulteen et al., 2018; O'Brien, Duncan, et al., 2018).

Contemporary research in Ireland has found that Irish children and youth demonstrate poor levels of competence in both FMS, and a more recent domain known as functional movement (Farmer et al., 2017; O' Brien et al., 2016; O'Brien, Duncan, et al., 2018). FMS are described as the 'building blocks' of efficient and effective movement, akin to the letters of an alphabet in the language domain (Gallahue, Ozmun, & Goodway, 2012). FMS are generally categorised into three domains: object control (catching, kicking, dribbling, striking and throwing), locomotor (running, skipping, jumping for height & jumping for distance) and stability (balancing; New South Wales Department of Education and Training, 2000; Ulrich, 2000; Victoria Department of Education, 1996). Without achieving proficiency in these basic movement skills across the three domains, individuals may encounter a 'proficiency barrier', which can inhibit their progression to specialised sports skills (Seefeldt & Haubenstricker, 1982). FMS are not learned automatically through maturation for most youths, and require opportunities for practice, encouragement, and instruction in an ecologically sound environment (Gallahue, Ozmun, & Goodway, 2012). Sex differences in FMS performance are noted often in research across childhood to adolescence, with males often outperforming females in object control skills, and females often outperforming males in the locomotor skill subset (Bolger et al., 2018; Breslin et al., 2012; Foweather, 2010; O' Brien et al., 2016).

Similar to FMS, functional movements are observable movement patterns, which are indicative of youth MC (O'Brien, Duncan, et al., 2018). Functional movement proficiency has also been linked to health outcomes, such as weight status in youth (Duncan et al., 2013). In addition, evidence has

suggested that functional movement and PA have a relationship in children and youth, however, this relationship is not as strong, when compared to weight status (Duncan & Stanley, 2012). Sex differences have been noted in functional movement performance, with some studies finding that males have a significantly higher mean overall composite score (Abraham et al., 2015; Anderson et al., 2015), however, other studies have reported significant differences at the individual movement pattern level, specifically male dominance in the trunk stability push-up, and female dominance in the active straight leg raise (Silva et al., 2019). Conversely, O'Brien et al. (2018; N = 219) found that females had a significantly higher mean overall composite functional movement score, when using the Functional Movement Screen (FMS™) tool, yet, the authors also found individual sex-based differences within specific movement patterns. Functional movement research in general adolescent populations is still emerging, as most studies to date have either focused on athletic or adult populations (Anderson et al., 2015; Bock et al., 2016; Fox et al., 2014). Of the research that has been conducted cross-culturally (India, USA, Ireland) amongst school-going adolescent populations, results consistently report average to low levels of functional movement (Abraham et al., 2015; Coker, 2018; O'Brien, Duncan, et al., 2018)

Tompsett et al. (2014) previously suggested that there may be links between what they term 'foundational movements' (squat, lunge, brace, pull, push, hinge and rotation) and FMS. For example, Tompsett et al. (2014) compared the squat motion with that of the preparatory and landing phases of a vertical jump. These 'foundational movements' also seem to parallel with some of the existing functional movements in the well-established FMS™

assessment instrument (i.e. the deep squat, in-line lunge, rotary stability and the trunk stability push-up; Cook et al., 1998). The associations between FMS and functional movement is a very under-researched area, however, a recent study, compared FMS™ performances with product measures of MC (i.e. throw and kick velocity) finding links between FMS™ composite scores and stability elements of MC (Silva et al., 2019). O'Brien et al. (2018) studied FMS and functional movement amongst a sample Irish adolescent population (N = 219, mean age = 14.45 ± 0.96 years), however, this study did not examine associations between these two constructs in terms of actual MC. Hulteen et al. (2018) argued for broadening the scope of FMS by including non-traditional FMS skills, under a more holistic term of foundational movement skills (not explicitly linked to the foundational movement discussed in Tompsett et al. (2014). These are defined as *"goal directed movement patterns that directly and indirectly impact an individual's capability to be physically active and that can continue to be developed to enhance PA participation and promote health across the lifespan"* (Hulteen et al., 2018, p. 1533).

In Ireland, research examining FMS and functional movement proficiency has shown that Irish adolescents demonstrate 'alarmingly' low levels of actual MC (Lester et al., 2017; McGrane et al., 2017; O' Brien et al., 2016; O'Brien, Duncan, et al., 2018). The purpose of this study is to investigate current levels of FMS and functional movement proficiency, as well as sex differences in these levels, amongst Irish adolescents, and to examine whether any associations between FMS and functional movement may exist.

3.3 Methods

3.3.1 Overview

Cross sectional baseline data were gathered as part of a larger study seeking to evaluate the effectiveness of a Physical Education (PE)-based adolescent MC intervention in Ireland. Data were collected in Irish second-level schools over a two-week period in January and February 2019. Measurements relevant to this baseline study included FMS, FMS™ and the anthropometric measures of height and body mass (kg).

Ethical approval for this study was granted by the Social Research Ethics Committee (SREC) in University College Cork (November 2018). All named researchers of the school-based project are qualified post-primary specialist PE teachers, as recognised by the Teaching Council of Ireland. Approval for each school's participation in the study was sought and obtained from the respective school Principal (or Deputy Principal). Researchers also gave a comprehensive brief of the data collection processes to the PE teachers at each participating school. Following principal and PE teacher consent to take part in the study, informed parental consent and child assent forms were distributed to the participating class groups. Only those who returned forms which indicated parental consent and child assent were permitted to participate in the data collection assessment. Participants were free to withdraw from the study at any time, without need for a reason.

3.3.2 Participants and Environment

Fourteen suburban second-level schools from County Cork (region of the province of Munster), Ireland were invited to partake in the study (5

socioeconomically disadvantaged mixed-sex schools, 5 all-male schools, and 4 all-female schools). Only schools with a school hall were approached for selection due to testing requirements. Of these fourteen schools, six were selected for inclusion: Two male only schools, two female only schools and two mixed-sex Delivering Equality of Opportunity in Schools (DEIS) (a programme designed to give tailored support to schools with a high concentration of socioeconomically disadvantage) schools (Department of Education and Skills, 2017). Three classes were then selected from years one to years three across the participating schools (12 – 16 years old). Of the 486 potential participants approached, 373 (47.7% girls) participants provided consent/assent, and were present for testing (uptake rate = 76.74%), with a mean age of 14.38 ± 0.86 years (age range: 12.23 – 16.37 years).

3.3.3 Data Collection

All field researchers involved in data collection were required to undertake 2-hour rigorous specialised training workshops on 2 occasions, specifically to equip them with the knowledge and skills to accurately implement the measurement protocol of FMS and the FMS™. Field researchers were provided with an instructional handbook (See Appendix F) at the beginning of the workshops, which outlined their role in the data collections process, and instructions on how to implement the protocol accurately. The workshops entailed an objective process, which delineated how to implement the testing as per the respective specifications of the testing measures. Measurements of FMS, FMS™ and anthropometric measurements were assessed during a 120-minute PE class period, with a maximum of 30

student participants per data collection session. To ensure anonymity, each participant was given a unique code before the beginning of testing.

3.3.4 Measurements

Measurements of movement (FMS and FMS™) were administered together during the same 120-minute PE class, using a station-based approach. All 17 movements (10 FMS & seven functional movements) were divided among the five stations, which were carefully selected to ensure equal time duration per station. Students were grouped accordingly and rotated together to each of the stations, until all groups had completed each of the five stations. All movement performances were video recorded using Apple iPads (4th and 5th Gen. Apple iPad, Apple Inc, California, United States of America). Utilising these recordings, the principal investigators later scored the seventeen movements.

3.3.4.1 Fundamental Movement Skills

Ten FMS were tested and scored across the locomotor (maximum score = 34), object control (maximum score = 40) and stability (maximum score = 10) FMS subsets as part of this study: vertical jump, horizontal jump, run, skip (locomotor); catch, kick, two-handed strike, overhand throw and stationary dribble (object control) and balance (stability). Measurement of FMS was carried out using a combination of the Test of Gross Motor Development (TGMD; Ulrich, 1985; skip), TGMD-2 (Ulrich, 2000; horizontal jump, run, catch, kick, two-handed strike, stationery dribble, and overhand throw) and the Get Skilled: Get Active teaching resource (vertical jump and balance; New South Wales Department of Education and Training, 2000). Construct validity and reliability of the selected FMS assessments have been established cross

culturally in large samples and reported in systemic analyses of motor assessment (Cools, Martelaer, Samaey, & Andries, 2009; Evaggelinou, Tsigilis, & Papa, 2002; & Valentini, 2012; Ulrich, 1985). The ten skills outlined above were selected due to their relevance in the Irish sporting and PE context, in line with previously reported objective measurements of Irish adolescents (O' Brien et al., 2016). Inter-rater reliability for the TGMD-2 has been established (Barnett, Minto, Lander, & Hardy, 2014; Kim et al., 2014).

Participants were informed about the testing procedures (e.g., first performance being a practice performance and second and third performances being trial performances) prior to station allocation. Before each FMS performance, a field researcher demonstrated the correct technique on one occasion for the participants to observe. Feedback was not given during or after performances of the skill. These protocol are consistent with previous Irish research in FMS (Lester et al., 2017; McGrane et al., 2017; O' Brien et al., 2016)

3.3.4.2 Functional Movement Screen™

The Functional Movement Screen™ (FMS™) (Cook et al., 1998, 2006b, 2006a) is a physical activity pre-participation screening tool, which assesses quality and function of movement to determine if individuals lack certain movement capabilities (Cook et al., 2006b, 2006a; Cook, Burton, Hoogenboom, & Voight, 2014). Inter-rater reliability for the FMS™ has been previously established (Minick et al., 2010; Teyhen et al., 2012). Seven movements were assessed as part of the FMS™: active straight leg raise, deep squat, in-line lunge, hurdle step, rotary stability, shoulder mobility and trunk stability push-up (Cook et al., 1998). Testing procedures in line with the

established guidelines for administering the FMS™ (Cook et al., 2006b, 2006a) were adhered to. Field researchers delivered movement specific pre-determined verbal instructions to participants during testing, as per the FMS™ protocol.

The FMS™ scores participants between zero to three on their performances of the seven aforementioned movements (Cook, 2010). An individual's full score for any movement is denoted as their 'raw' score. A raw score of zero was given if pain was reported by the participant at any time during testing. A raw score of one was given to a participant, if they were unable to complete a movement and is viewed as a dysfunctional performance of the movement (Coker, 2018; Cook et al., 2014). As such, in this study, a raw score of '1' on a movement was classified as a 'dysfunctional' movement performance. A raw score of two was given to a participant if they were able to complete the movement using some compensations (for example, lifting one's heels during the deep squat). A raw score of three was given only if the participant completed the movement, as specified without any use of compensatory movements.

Five of the seven movement patterns were completed bilaterally: active straight leg raise, in-line lunge, hurdle step, rotary stability, and shoulder mobility. Scores were given for each side and, if the scores were not equal, the lower of the two scores was selected to make up the participant's final or 'raw' score for the skill. A composite FMS™ score (out of a possible 21) was derived by summing the seven raw scores together in accordance with the guidelines of screening (Cook et al., 2006b, 2006a).

3.3.4.3 Anthropometric Measurements

Measurements of height (cm) and body mass (kg) were taken for the purpose of compiling Body Mass Index (BMI) scores for the participants. These measurements were conducted during the testing, after participants completed one of the stations. Height was measured using a portable stadiometer (Seca 213, Birmingham, United Kingdom). Weight was measured using a weighing scales (Omron BF508, Illinois, United States of America) to the nearest 0.1 of a kilogram (kg). BMI was calculated and participants were classified into one of four categories according to Cole and Lobstein (2012): underweight, normal weight, overweight and obese.

3.3.5 Data Analysis:

Prior to data scoring, inter-rater reliability was established between principal investigators on 10% of the dataset. Two researchers coded 10% of the data across all skills separately, and were required to meet a 95% inter-rater agreement (Lester et al., 2017; Logan et al., 2017). Both FMS and FMS™ datasets were analysed using the IBM Statistical Package for the Social Sciences (SPSS) version 25.0 for Windows. Participants with missing data due to errors regarding camera function/angle were omitted from the dataset. Descriptive statistics such as means and frequencies for all ten FMS and seven functional movements, were calculated at the skill raw score level of analysis. Descriptive statistics were also used to discern sample information (e.g. mean age, sex etc.). Chi-square tests for independence were used to determine group differences in both BMI classifications and dysfunctional movement performance. For the purpose of comparison across variables with differing maximal values, mean raw scores were converted into normalised

scores in both the FMS and FMS™ analysis. Independent samples t-test analysis was used to determine sex-based differences in mean FMS and functional movement performances. Bivariate correlations between FMS and functional movements were carried out to determine any associations between variables, with r = 0.10 – 0.29 denoting a low correlation, r = 0.30 - 0.49 denoting a moderate correlation, and $r \geq 0.50$ denoting a strong correlation (J. Cohen, 1988) . Statistical significance was set at $p < 0.05$.

3.4 Results

373 participants took part in this study (178 girls [47.72%],195 boys [52.28%]), 22.1% of participants were classified as overweight or obese, while 6.1% were categorised as underweight. The broad data range allows for examination of movement proficiency via analysis of FMS mean scores and functional movement between the sexes in Irish early adolescents, as well as an examination of the inter-relatedness between variables.

3.4.1 Fundamental Movement Skills

No participant achieved complete mastery of all FMS, with the highest score being 78, and the lowest score being 43, out of a possible total FMS gross motor score of 84. The mean overall composite score found in this study was 64.90 ± 6.20. Independent samples t-tests analysis showed a significant sex-based difference in the overall gross motor score, with males outperforming females; $t(322) = -2.37$, $p = 0.018$. Sex differences were also discovered in both the object control and the locomotor skills subsets, with males scoring significantly higher in the object control subset; $t(292.01) = -7.22$, $p = 0.001$, and females scoring significantly higher in the locomotor skills

subset; $t(349) = 3.31$, p = <0.001. Figure 3.1 highlights FMS proficiency differences between sexes, mean raw scores have been converted into normalised scores for the purpose of comparison across variables with different maximum raw scores. At the individual skill level, males outperformed females in the overhand throw $t(330.70) = -9.88$, p = <0.001 and the kick t(360) = -4.54, p = <0.001. Females, however, outperformed males in the skip; t(362) = 2.36, p = 0.019, the horizontal jump; t(341.60) = 2.56, p = 0.018 and the vertical jump; t(363) = 2.92, p = 0.003.

3.4.2 Functional Movement

For the FMS™ assessment, the highest score achieved was 17, and the lowest score was seven, out of a possible total score of 21. The overall mean composite score was 12.01 ± 1.97. Independent samples t-tests showed that significant sex differences in mean scores were present in several functional movements, however, as displayed in Figure 3.2, there was no significant sex-based difference in the overall raw functional movement composite score. Males significantly outperformed females in the hurdle step t(316.93) = - 7.67, p <0.001, the in-line lunge $t(316.34) = - 4.00$, p <0.001 and the trunk stability push-up $t(354.39) = -6.34$, p <0.001. Females significantly outperformed males in the active straight leg raise $t(362) = 8.52$, p <0.001 and the rotary stability $t(348.71) = 2.11$, p = 0.035.

Figure 3.3 shows a sex-based comparison of the percentage of dysfunctional FMS™ scores (i.e. participants who scored a ‘1’ in the relevant movement pattern). Results show that males demonstrated significantly more dysfunction in the active straight leg raise (57.40% of males dysfunctional vs 23% of females dysfunctional), deep squat (62.40% males dysfunctional vs

50.90% of females dysfunctional), and rotary stability (24.70% of males dysfunctional vs 16.30% of females dysfunctional) movements, whereas females were significantly more dysfunctional in the hurdle step (12.20% of males dysfunctional vs 49.10% females dysfunctional), in-line lunge (17.20% of males dysfunctional vs 37% of females dysfunctional) and the trunk stability push-up (39% of males dysfunctional vs 73.80% of females dysfunctional).

3.4.3 Associations between FMS and Functional Movement

Bivariate correlations were carried out between FMS overall, object control, locomotor, and stability subsets and the seven functional movements, as well as the overall functional movement composite score, to discern if any association exists between the movement constructs (see Table 3.1). Moderate associations were found between the overall composite FMS and functional movement mean scores $r = 0.375$, $p \leq 0.001$, $R^2 = 0.141$. A weak to moderate correlation was also found between the overall locomotor mean score, and the overall functional movement composite mean score $r = 0.30$, $p \leq 0.001$, $R^2 = 0.087$.

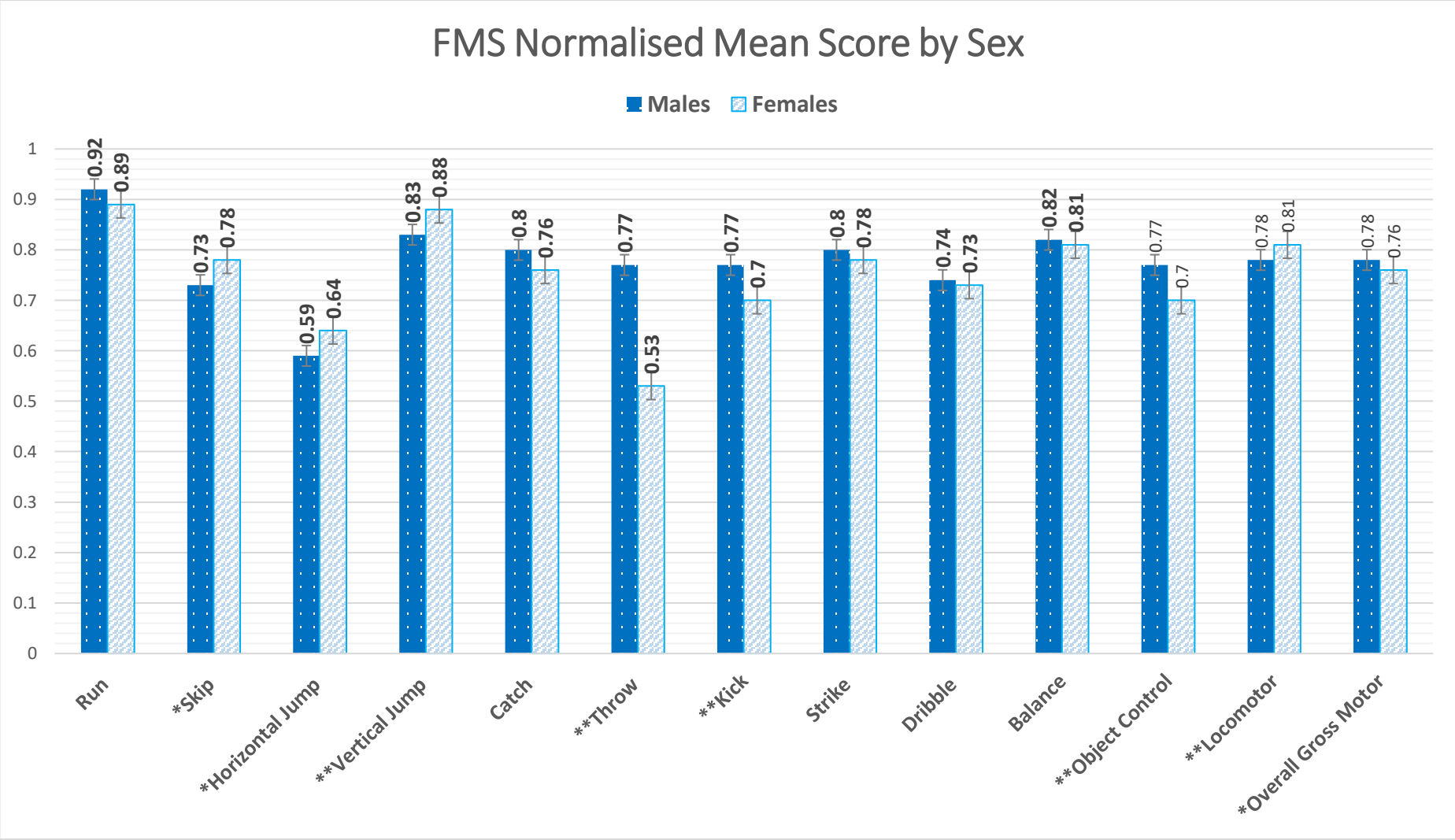

*Figure 3.3: Normalised Fundamental Movement Skill Proficiency Mean Score by Sex. *Denotes Significance at the 0.05 Level. **Denotes Significance at the 0.01 Level.*

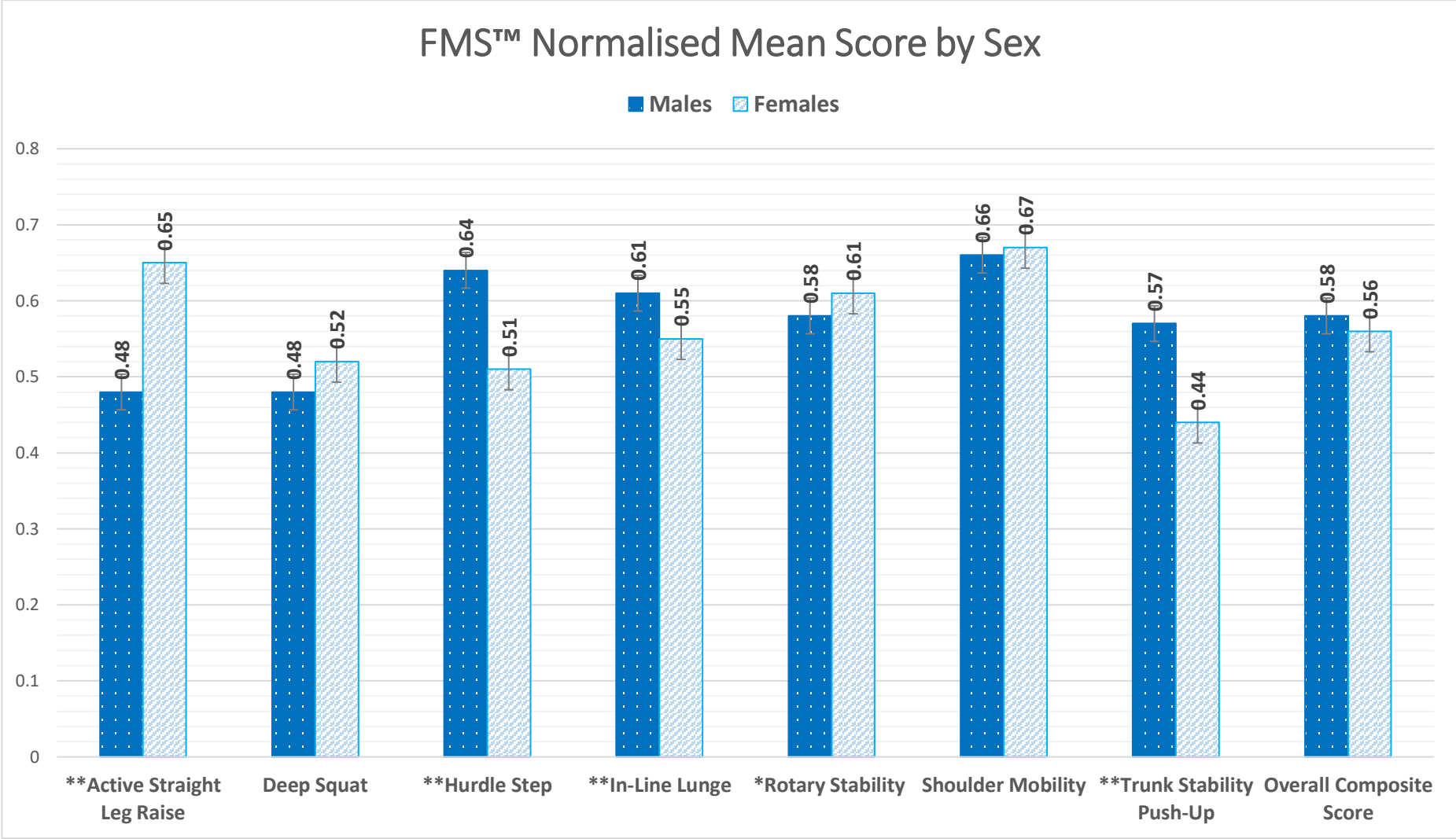

*Figure 3.2: Normalised Functional Movement Screen™ Mean Score by Sex. *Denotes Significance at the 0.05 Level. **Denotes Significance at the 0.01 Level.*

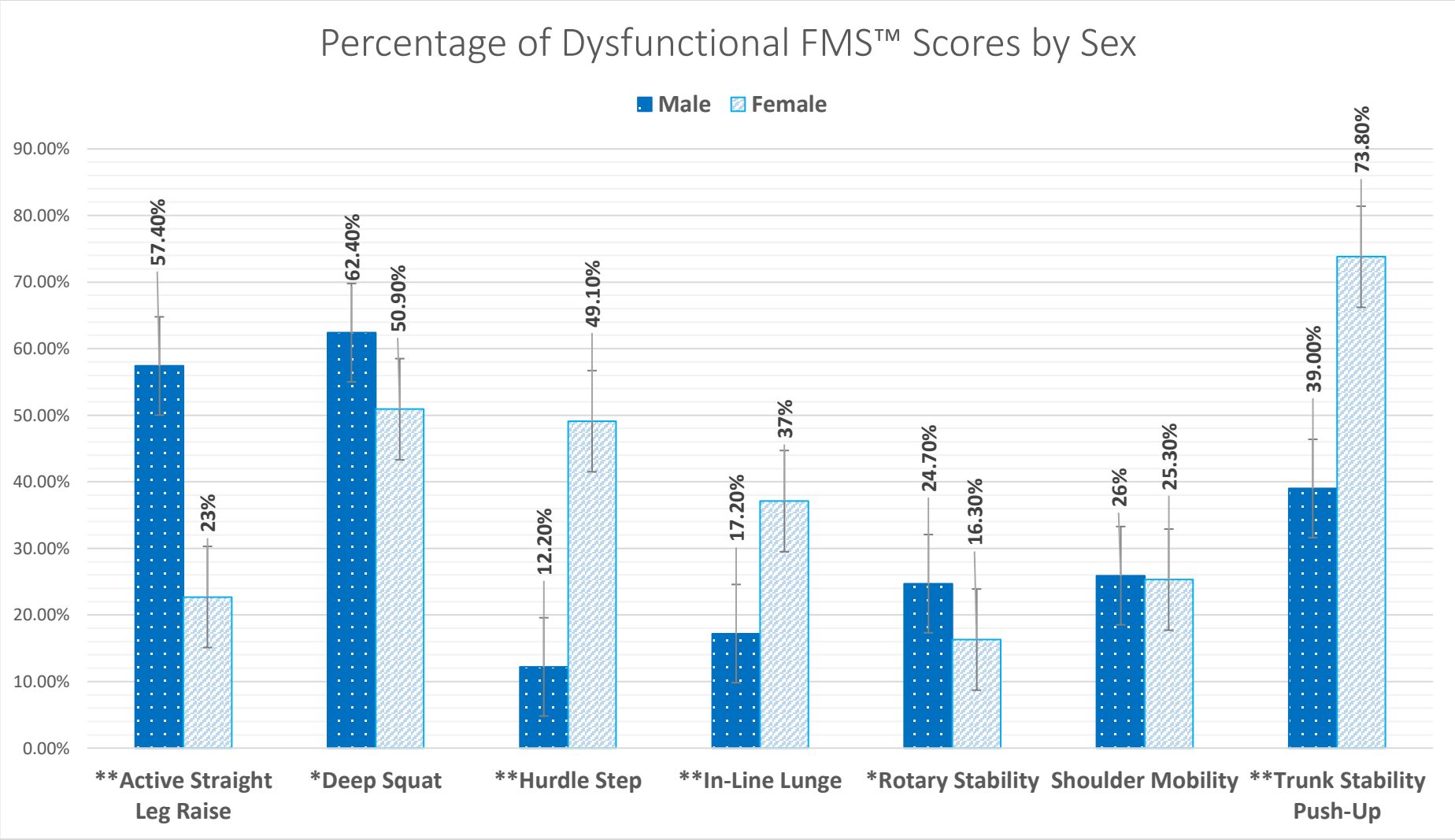

*Figure 4.3: Percentage of Participants who scored a 'Dysfunctional' score of '1' by Sex. *Denotes Significance at the 0.05 Level. **Denotes Significance at the 0.01 Level.*

Functional Movement Screen™	Active Straight Leg Raise	Deep Squat	In-Line Lunge	Hurdle Step	Rotary Stability	Shoulder Mobility	Trunk Stability Push-Up	Overall FMS™
Fundamental Movement Skills Subsets								
Overall Locomotor	**.216****	**.182****	**.015**	**.142***	**.119***	**.173****	**.146****	**.300****
Overall Object Control	**-.066**	**-.025**	**.215****	**.238****	**.108**	**.077**	**.218****	**.215****
Overall Stability	**.068**	**.095**	**.043**	**.150****	**.187****	**.135****	**.103**	**.224****
Overall Gross Motor Score	**.097**	**.131***	**.143***	**.272****	**.182****	**.204****	**.244****	**.375****

*Table 3.1: Correlations (R-values) between FMS and Functional Movement Screen™ Scores. *Denotes Statistical Significance at the 0.05 Level. **Denotes Statistical Significance at the 0.01 Level.*

3.5 Discussion

The purpose of this study was to examine current levels of movement proficiency of both FMS and functional movement in early Irish adolescent youth, via sex-based comparison, and to discern if any associations between both movement constructs exist. This study served to add to the growing field of research into MC currently being carried out in Ireland (Bolger et al., 2018; Farmer et al., 2017; Lester et al., 2017; O' Brien et al., 2016; O'Brien, Duncan, et al., 2018), with a specific focus on evaluating FMS and movement patterns (functional movement) in early adolescent populations. Overall, current findings indicate low levels of FMS and functional movement proficiency, high levels of functional movement dysfunctionality among the adolescent sample, as well as a moderate association between FMS and functional movement performances.

FMS proficiency has well-established links to numerous health benefits in children and adolescents, with evidence consistently suggesting that FMS are positively associated with PA and cardiorespiratory fitness, and negatively associated with weight status (Bryant et al., 2014; Lubans et al., 2010). Results of the present study indicate that Irish adolescents have generally poor levels of FMS proficiency, with an overall mean score of 64.90 ± 6.20 (out of a possible 84). This dearth of proficiency is exacerbated by research which suggests that mastery of most FMS is achievable by 6 years of age (Gallahue, Ozmun, & Goodway, 2012). The findings support previous work in the area of adolescent FMS in Ireland, which also reported low levels of FMS proficiency (Belton, O'Brien, Meegan, Woods, & Issartel, 2014; Lester et al., 2017).

Interestingly, the present study found that the horizontal jump was the poorest performed skill amongst this cohort of Irish adolescents, with poor jumping performances also reported in two previous adolescent studies in Ireland (Lester et al., 2017; O' Brien et al., 2016). These poor FMS results can be viewed in conjunction with a recent large scale research study in Ireland (n = 2098, age range 5 – 12 years), which reported overall poor levels of FMS proficiency in a primary school cohort, with FMS proficiency declining after the age of ten (Behan et al., 2019). These findings suggest a consistent and emergent trend towards FMS deficiency amongst Irish youth, which remains across the adolescent threshold, that may in turn be linked to recently observed large-scale declines in Irish youth PA (Woods et al., 2010, 2018).

Sex-based differences in FMS performance from childhood to adolescence have been repeatedly reported cross-culturally, with some findings reporting that females outperform males in the locomotor subset, while most empirical data reports that males outperform females in the object control subset (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Bolger et al., 2018; Goodway, Robinson, & Crowe, 2010; O' Brien et al., 2016). The results of this study show that males outperformed females in both overall FMS proficiency, and the object control subset, while females outperformed males in the locomotor subset. Significant differences were found between the sexes in five individual FMS, with females performing significantly better in the skip, horizontal jump and vertical jump, and males performing significantly better in the throw and kick. The observed low levels of FMS proficiency, specifically amongst female adolescents (in the object control domain) is supported by previous Irish research (Farmer et al., 2017).

The observed sex difference may be attributed to a mixture of both natural and ecological factors (Eather et al., 2018). Goodway et al. (2010) suggested that sex differences in FMS, particularly the object control domain, may arise from the difference in reinforcement which male and female children receive to participate in object control related games. The types of PA in which male and females choose to participate in may also be a factor. A recent nationally representative surveillance study across the island of Ireland (n = 6'651; age range 10-18 years; 53% female) indicated that the most popular sports for young males were entirely object control dominant (soccer, Gaelic football, hurling, rugby and basketball), whereas a combined mixture of both locomotor and object control sports are most popular for females (Gaelic football, dance, swimming, camogie and soccer; Woods et al., 2018). The ecological explanation of these sex differences is supported by data from a study of Singaporean youth (N = 244, 112 female, age range 6 – 11 years) which reported no differences between sex in FMS performances, and the authors attributed this observation to the Singaporean primary school PE curriculum's focus on equal sex opportunities for practice and development of FMS (Mukherjee et al., 2017).

Interestingly, a study (McGivern et al., 2012) in the field of psychology may shed some light on the natural aspects of the observed sex differences in the object control subset. McGivern et al. (2012, p. e32238) found that males demonstrated a 'large and consistent male advantage for accurately estimating the vector of a moving ball', that is to say, that males were more accurate in tracking an object's movements, when compared to females in the study. It is important to recognise the potential impact of the sex differences in

object control skills, as this domain of movement has been linked with increased PA, more so than locomotor skill proficiency (Cohen et al., 2014). Farmer et al. (2017) have previously identified the need for developing female FMS proficiency in the Irish context, asserting that a movement-oriented intervention may be required to address the deficiencies.

In terms of the *'new kid on the block'* (Tremblay & Lloyd, 2010), functional movement, low overall mean composite scores were found in this study, which are lower than previously reported FMS™ scores with adolescents (Abraham et al., 2015; Anderson et al., 2015; O'Brien, Duncan, et al., 2018; Portas, Parkin, Roberts, & Batterham, 2016). While there were no significant differences between males and females in their mean overall composite FMS™ scores, significant sex differences were noted for mean scores in four of the seven skills. Females significantly outperformed males in the active straight leg raise, which is in line with previous research findings (O'Brien, Duncan, et al., 2018; Silva et al., 2019). Males significantly outperformed females in the in-line lunge, hurdle step and trunk stability push-up. These findings are consistent with previous literature regarding the trunk stability push-up movement (Abraham et al., 2015; Anderson et al., 2015; O'Brien, Duncan, et al., 2018; Silva et al., 2019). Male superiority in the in-line lunge has also been previously reported in adolescent samples (Abraham et al., 2015; Anderson et al., 2015), although the authors reported a weak effect size, and suggested that the difference may be a result of lower strength and muscle activation in females.

Alarmingly, 91.7% of participants displayed movement dysfunction (a score of 1) in at least one of the seven assessed movements from the FMS™,

meaning that participants were unable to complete the required movement at all. The FMS™ is designed to screen for poor quality and compensatory movements across seven fundamental movement patterns, by identifying poor biomechanics and detecting the risk of injury (Cook et al., 2014). Mokha et al. (2016) examined scores of '1' under what they termed as 'limited' movement combined with asymmetries between right and left in bilateral movements finding that those who displayed 'limited' or asymmetrical movement were 2.73 times more likely to experience a musculoskeletal injury. Considering the level of dysfunctional movement observed in this Irish adolescent population (Figure 3.3), it seems that participants are inadequately prepared to take part in activity. This lack of preparedness is especially concerning considering adolescents' susceptibility to musculoskeletal injuries due to their growing bodies (Henschke et al., 2014; Paszkewicz et al., 2013).

In the current study, significant differences were apparent between males and females in terms of their functional movement dysfunction (score of '1') levels, in six of the seven functional movement assessments. Males were significantly more dysfunctional in the active straight leg raise, deep squat, and rotary stability movements, while females were significantly more dysfunctional in the hurdle step, in-line lunge and the trunk stability push-up. These results are somewhat consistent at the individual movement pattern level, as two previous studies, Abraham et al. (2015; N = 1005, age range 10 – 17 years), and Anderson et al. (2015; N = 60, age range 13 – 18 years), also found that males performed significantly better than females in the in-line lunge and the trunk stability push-up. The difference in trunk stability push-up scores may be attributed to boys increased strength levels after puberty, as this

movement requires upper body strength for successful completion (Beenakker, Van der Hoeven, Fock, & Maurits, 2001; Ervin, Fryar, Wang, Miller, & Ogden, 2014; Schneider & Meyer, 2005). Cook et al. (2014) attribute poor performance in the trunk stability push-up to poor stability of the trunk and core stabilisers (Cook et al., 2014).

Lester et al. (2017) conducted a behavioural component level analysis of functional movement amongst Irish adolescents and identified thoracic spine limitations as a common issue in the performance of the in-line lunge. Heneghan et al. (2018) found that those who spend >7 hours/day sitting and completing <150 mins/week of PA showed reduced thoracic spine mobility. Woods et al. (2018) reported that 14% of Irish second-level males reached the specified PA guidelines, compared to 7% of Irish second-level females. In the study, females also displayed higher levels of sedentary time per day (6.8 hours/day), when compared to males (6.4 hours/day) (Woods et al., 2018).

A significant difference was also noted between males and females in the active straight leg raise, with more than half of males demonstrating dysfunction in the movement performance, compared to just 23% of females. The active straight leg raise movement assesses hamstring/calf flexibility, hip mobility, as well as pelvic and core stability, and poor performances in this movement may be attributed to poor hamstring flexibility, and inadequate hip mobility (Cook et al., 2014). Females have been identified as having greater joint laxity and decreased muscular stiffness, when compared to males (Renstrom et al., 2008). Several studies have linked poorer overall functional movement composite and asymmetrical scores (FMS™) with a greater risk of injury, however, many of these studies were conducted on adult and/or high-

performance individuals, rather than a more general school-going adolescent sample (Attwood, Roberts, Trewartha, England, & Stokes, 2019; Chalmers et al., 2017; Kiesel et al., 2007). It is worth noting, however, that a previous meta-analysis by did not find adequate evidence to support the FMS™ as an injury prediction tool (Dorrel et al., 2015).

Two moderate associations were found between FMS and functional movement amongst this Irish adolescent population, as displayed in Table 3.1; locomotor and overall FMS™, and overall FMS and Overall FMS™. Object control demonstrated the weakest association to the overall FMS™ composite score, which may be due to only three of the FMS™ movements requiring control of an object (deep squat, in-line lunge and hurdle step), and the object is a simple dowel.

Few studies have examined links between FMS and functional movement patterns, however, the Tompsett et al. (2014) coining of the term ‘foundational movements’, appears to relate closely with the movement patterns of the FMS™, which Cook et al. (2006b) described as a fundamental to sport and PA participation. Silva et al. (2019) studied the relationships between FMS™ scores and MC product outcomes across the locomotor, stability, and object control subsets (e.g. shuttle run, lateral jumps, shifting platforms, throwing velocity and kicking velocity). Unlike the present study which found a moderate association between the locomotor construct of FMS and the overall FMS™ composite score performance, Silva et al. (2019) found that FMS™ scores were only associated with the stability element of MC.

Results of the present study indicated a moderate correlation between overall gross total FMS and overall FMS™ composite scores (r = 0.375, p < 0.001, R^2 = 0.141), which suggests that there may be an association between both domains. This association may arise from biomechanical similarities which can be found between certain functional movements and FMS (e.g. squat flexion and the preparatory and landing phases of the vertical jump; Tompsett et al., 2014). This may also have arisen through FMS and FMS™ being positively associated with PA (Duncan & Stanley, 2012; Okely et al., 2001), and so the more active participants may be scoring highly in both constructs. Overall, at the individual movement level of analysis, the present study has demonstrated a small association between many of the functional movement scores and the FMS subsets, however, further research should be carried out to determine if there exists a causal association between these movement constructs.

3.6 Limitations of the Study

A potential limitation of this study is all the participants were selected from one county in the south of Ireland from an urban setting only, which may not be representative of Irish adolescents from rural backgrounds. The lack of multiple different movements in the stability subset of FMS is also a limitation of the study, as this category does not display as much variation as the object control and locomotor subsets. A more thorough examination of the link between the stability FMS subset and FMS™ may have been possible if the stability subset of FMS had examined stability through multiple skills. Nested data were not controlled for in the analysis of this dataset. A lack of FMS™

data amongst non-sporting adolescent populations also limits the interpretation of results amongst this population.

3.7 Conclusion

The results of this study indicate that Irish adolescents display poor FMS and functional movement proficiency, which is continuing a worrying trend in this specific population in Ireland (Farmer et al., 2017; Lester et al., 2017). The moderate associations between FMS and FMS™ found in this cross-sectional study suggest that the relationship between these two movement constructs warrants further research. Indeed, it may be more appropriate to view these two MC constructs as foundational movements (Hulteen et al., 2018), as together, they represent movements which are important for PA throughout the lifespan, and offer a more holistic view of motor development. Given the observed low levels of adolescent FMS and functional movement proficiency in Irish adolescents, it seems that an intervention targeting the development of holistic foundational movement proficiency amongst early adolescent Irish youths may be beneficial (Lester et al., 2017).

3.8 Acknowledgements

We would like to acknowledge the school principals, teachers and students who participated in this study and thank them for their co-operation during data collection. We would also like to thank the undergraduate students of the Sports Studies and Physical Education course in University College Cork for their contributions to the data collection process. This research was funded by Sport Ireland's Dormant Accounts Funding (2018).

3.9 Links Between Chapter 3 and Chapter 4

3.9.1 Purpose of Chapter III

Chapter III serves as an examination of actual adolescent MC across both the FMS and functional movement constructs. This examination was conducted to reinforce Project FLAME's actual MC evidence base across a larger and more diverse sample of adolescents. The results of this study reinforce and provide additional justification for the need for Project FLAME as a force to ameliorate the low levels of actual MC found in Irish adolescent youth. This study also functioned to examine the association between FMS and functional movements. The finding of moderate correlational association between the constructs supports the combination of both constructs in the Project FLAME intervention as performances in both constructs display some form of association. This study also introduced a new MC assessment area of intrigue for Project FLAME in the form of dysfunctional movement (when the individual cannot complete the specified movement) offering a new avenue for Project FLAME to explore. This variable may be an important for consideration in future evaluations of Project FLAME's effectiveness as testing can be carried out to confirm if the intervention can ameliorate youth's dysfunctional movement performances.

3.9.2 Purpose of Chapter IV

Chapter IV aims to examine pre-service teachers' perceptions of Project FLAME via a FG discussion following their completion of a 2-hour practical CPD style course in which the participants used the Project FLAME resources to administer Project FLAME movement development activities. This study served firstly to discern if practising pre-service teacher's

perceptions of adolescent MC corroborated with the findings of Chapter III. This would determine if practising pre-service teachers' experience reinforces the need for the Project FLAME intervention or not. Secondly, the perceptions of the FG participants of the original Project FLAME and its resources were collected and the data were analysed for the purpose of refining and developing the original iteration. The voice of the teacher stakeholder is vital to the development of the project as they are the agents who deliver this intervention on the ground. Through the FG feedback, several alterations and refinements were made to the Project FLAME intervention and resources which are detailed within the chapter.

3.9.3 Implications of Chapter III and Chapter IV

The data collected as a part of Study 1 serve to develop Project FLAME's evidence base through examining a large and diversified population sample. Similarly, the data evidence found in Study 2 were utilised to refine and develop Project FLAME and its resources, leading specifically to updates in the 'Practitioner's Handbook' (See Appendix D). The combination of these qualitative and quantitative data across both studies informed the refinement and development of the Project FLAME intervention so that it is ready for its next stage of development as a Randomised Controlled Trial.

Thesis Chapter IV (Study II)

Title: Improving Motor Competence in Irish Adolescents: Refining and Developing the Project FLAME Intervention

4.1 Abstract

Background: Irish adolescents possess substandard levels of fundamental movement skills (FMS) and functional movement. Specialist Physical Education (PE) teachers are essential contributors to the development of motor competence (MC) in adolescent youth. The purpose of this study is to ascertain the thoughts and perceptions of a group of pre-service Physical Education teachers in order to refine and develop the design of Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention.

Methods: A focus group consisting of six pre-service PE teachers from five second-level schools in socioeconomically disadvantaged areas of County Cork, Ireland was conducted, following participants receipt of a practical workshop on the delivery of the Project FLAME intervention. The focus group was semi-structured and targeted two points of discussion; 1) teachers' views on their students' MC levels; and 2) teachers' perceptions of the existing Project FLAME intervention and its accompanying resources. The focus group was audio recorded and the recording was subsequently transcribed verbatim. Data from the focus group were thematically analysed.

Results: Analysis of the focus group data revealed several themes for each of the two discussion points. Discussion on the topic of adolescent MC levels

centered around: the impact of physical activity and sport participation on MC; teachers' observations of poor MC with notable age-related declines in MC; and the existence of a substantial proficiency gap between high and low MC levels in adolescents. The second discussion topic on the intervention and resources revealed: teachers perceived the Project FLAME intervention and its accompanying resources as a potential facilitator for their pedagogical practice; elements of the resource need to be tailored further for accessible and practical teacher use.

Discussion: Refinements and developments to the Project FLAME intervention were attained and considered based on feedback from the pre-service PE teachers. Project FLAME is a unique intervention, which targets both fundamental and functional movement as part of a holistic MC assessment strategy. This study provides an overview of the original Project FLAME intervention, as well as an evidence-based rationale for the refinements and developments to the original Project FLAME MC intervention in the Irish education setting. The modified project design offers a viable, adaptable, and targeted whole-school approach for MC, and subsequent physical activity promotion in adolescents.

Keywords: Motor Development; Intervention; Fundamental Movement Skills; Functional Movement Screen™; Physical Education; Covid-19;

4.2 Introduction

Physical inactivity was estimated to account for 9% of premature mortality in 2008, with a health impact comparable to smoking and obesity; well-established links exist between physical activity (PA) and health outcomes, such as coronary heart disease, breast/colon cancer, and type II diabetes, (Lee et al., 2012). PA can play an important role in the prevention of obesity during adolescence (Hills et al., 2011). Over the past decade, large scale studies of Irish adolescents have demonstrated a consistently low and downward trend in PA, with only 12% of participants meeting the PA guidelines of 60 minutes moderate-to-vigorous-physical activity (MVPA) per day in 2010 (Woods et al.), and this statistic fell further to 10% in 2018 (Woods et al.). A worldwide study of PA found that adolescent physical inactivity (not meeting guidelines of 60 minutes MVPA per day) was at 78.4% for boys and 84.4% for girls respectively (Sallis et al., 2016). Irish adolescents are participating below the existing low global averages in terms of PA participation.

De Meester et al. (2018; N = 326; 48.5% male, mean age 9.50 ± 1.24 years) identified that a 'proficiency barrier' in motor competence (MC) may impact youth's MVPA participation, specifically 90% of those identified as having below average MC were also not meeting the 60 minute daily MVPA guideline. Furthermore, De Meester et al. (2018) found that children with high MC were 2.46 times more likely to meet the PA guidelines for health. According to Stodden's developmental model (2008), MC development acts reciprocally with PA to create positive spirals of PA engagement, in which better MC and higher PA are reported to lower the risk of obesity. Developing

MC in youth may therefore relieve some adolescent PA attrition and serve as an important avenue in the promotion of PA in youth populations.

Functional movement is an area of MC which is performed poorly by Irish adolescents (O'Brien, Duncan, et al., 2018). Functional movements entail multi-planar, multi-joint, strength, stability and mobility dependent movements, which allow the body to move with proper muscle and joint function (Abraham et al., 2015; Coker, 2018). Interestingly, preliminary research has identified an association between FMS and functional movement in measures such as stability (Kramer et al., 2019; Silva et al., 2019). Results of O'Brien's (2018) study of Irish adolescents showed similar but ultimately lower mean overall levels of functional movement (14.05 ± 2.48 out of a possible 21), when compared to Indian adolescents (Abraham et al., 2015 - mean score 14.59; CI 14.43 – 14.74). Duncan and Stanley (2012) proposed that children who are not functionally limited may enjoy activity and be more physically active than those who are functionally limited. Lester et al. (2017), highlighted the need to target both functional movement and FMS in Irish adolescents.

O'Brien et al. (2016), reported that Irish adolescents entering second-level schooling presented 'alarming' levels of FMS deficiency, with several other recent studies also reporting low FMS proficiency levels in Irish youth (Behan et al., 2019; Farmer et al., 2017; Lester et al., 2017). Behan et al. (2019; N = 2098; 47% female, age range 5 – 12 years) found a plateau and decline in children's FMS proficiency levels at the age of 10 years (near the end of primary schooling), with Lester et al. (2017) reporting that the dribble, throw and horizontal jump significantly declined from first to third year of second-level school. Lester et al. (2017) suggested that this decrease may be

a result of less time allotted to and spent in PA by adolescents, impacting muscular strength, leading to a lack of maturity in adolescent motor development. Targeting MC development in adolescents may serve to arrest the decline in FMS abilities and contribute to more PA and positive health outcomes for adolescents.

Effective interventions across PA, FMS, and functional movement are characterised by several key factors. These types of interventions are commonly led by PE teachers in schools in the case of FMS interventions, while successful functional movement interventions are often led by coaches (Lander, Barnett, Brown, & Telford, 2015; Mannocci et al., 2020; St. Laurent, Masteller, & Sirard, 2018; Tompsett, Sanders, Taylor, & Cobley, 2017). In order to incur a more sustainable change in MC and skill ability, multi-component interventions have been deemed the most efficacious strategy (Lai et al., 2014; Mannocci et al., 2020; Tompsett et al., 2017). In the Irish educational context, a multi-component, whole school, PE teacher led, and PE-based FMS intervention with second-level pupils (N = 420; mean age 12.78 ± 0.42 years) has been shown to effectively develop and sustain FMS and lead to sustained growth in MVPA levels two years after the intervention (Belton, McCarren, et al., 2019). The combination of PE, the school, and the home environments are highly effective as these types of programmes provide multiple engagements for students, and recognise the strong influence that peers and role models have in the influence of one's PA patterns (Mannocci et al., 2020; Petersen, Møller, Brønd, Jepsen, & Grøntved, 2020).

Functional movement interventions which focus on multi-planar movements in the body have been shown to be effective at promoting

improvements in MC assessment scores (Coker, 2018; St. Laurent et al., 2018; Wright et al., 2015). These interventions have utilised face-to-face teaching methods, which Tompsett et al. (2017) found to be most appropriate for FMS enhancement, particularly for novice learners. However, a multi-component diet and health intervention (using digital classes) has also previously demonstrated success in boosting functional capacity (Nourse et al., 2015).

While interventions focussed on direct teaching (teacher-led, highly structured) methods have evidence of being beneficial in improving FMS capacity in young and older childhood populations (Brian & Taunton, 2018; Dudley, Okely, Pearson, & Cotton, 2011), student-driven approaches may also be effective if the teacher is experienced. Tompsett et al. (2017) noted that FMS development environments which encourage learner autonomy, under the guidance of a specialist teacher who provides individualised tasks and feedback, can help to improve intervention responses and adherence by developing learner's perceived competence. Student-centred approaches are characterized by greater choice, support, and developmentally appropriate tasks, which has previously shown opportunities for students to experience success (Chan, Ha, & Ng, 2016; Chan et al., 2019). Lander et al. (2017) reported success in developing adolescent girls actual FMS competence through a student-centred teacher-led intervention focussed on creating a motivating learning climate.

Researchers recognise the importance of evaluating the perceptions of specialist PE teachers, as evidenced in Lander et al. (2016), who sought PE teachers' perceptions on the introduction of an FMS assessment tool in

schools. Similarly, in Ireland, qualitative research has been conducted with specialist PE teachers to gain an insight into their opinions and experiences with regards to implementing formative assessment in PE (Ní Chrónín & Cosgrave, 2013). A recent school-based PA intervention entitled 'Girls Active' in the United Kingdom included qualitative research methods to discern PE teachers' perceptions of the programme for the purpose of process evaluation (Gorely et al., 2019). Interestingly, Wang and Ha (2009) sought to qualitatively examine pre-service PE teachers' (8 females, 12 males) perspectives on using the Teaching Games for Understanding model in practice, commenting that in-service teachers may be more resistant to shift from traditional pedagogical methods. Butler (2005) noted that due to their energy and idealism, pre-service PE teachers represent potential agents of curricular change and innovation.

4.2.1 Theoretical Foundation of Project FLAME

From its inception, the Project FLAME intervention has been theoretically underpinned by the developmental model of MC, as proposed by Stodden et al. (2008), which is outlined below in Figure 4.1. Project FLAME aims to exploit the dynamic reciprocal relationship between MC and PA, with the long-term intention of creating positive cycles between PA engagement and MC development (Stodden et al., 2008). This theoretical underpinning is evidenced in research by Robinson et al. (2015), who reported a positive relationship between PA and MC across childhood. Perceived Motor Competence (PMC) is recognised as a mediator in the Stodden model. PMC refers to a person's own belief in how competently they can execute a particular skill (van Veen et al., 2019). Project FLAME aims to develop PMC through developing actual MC, while the positive, constructive environment

propelled by teachers will boost PMC in addition to MC (Chen, 2015). The development of MC is essential to avoid the potential creation of continuously compounding negative spirals of disengagement in PA, which could lead to negative health outcomes such as obesity (Stodden et al., 2008). The model also highlights the importance of health-related fitness as a mediating variable,

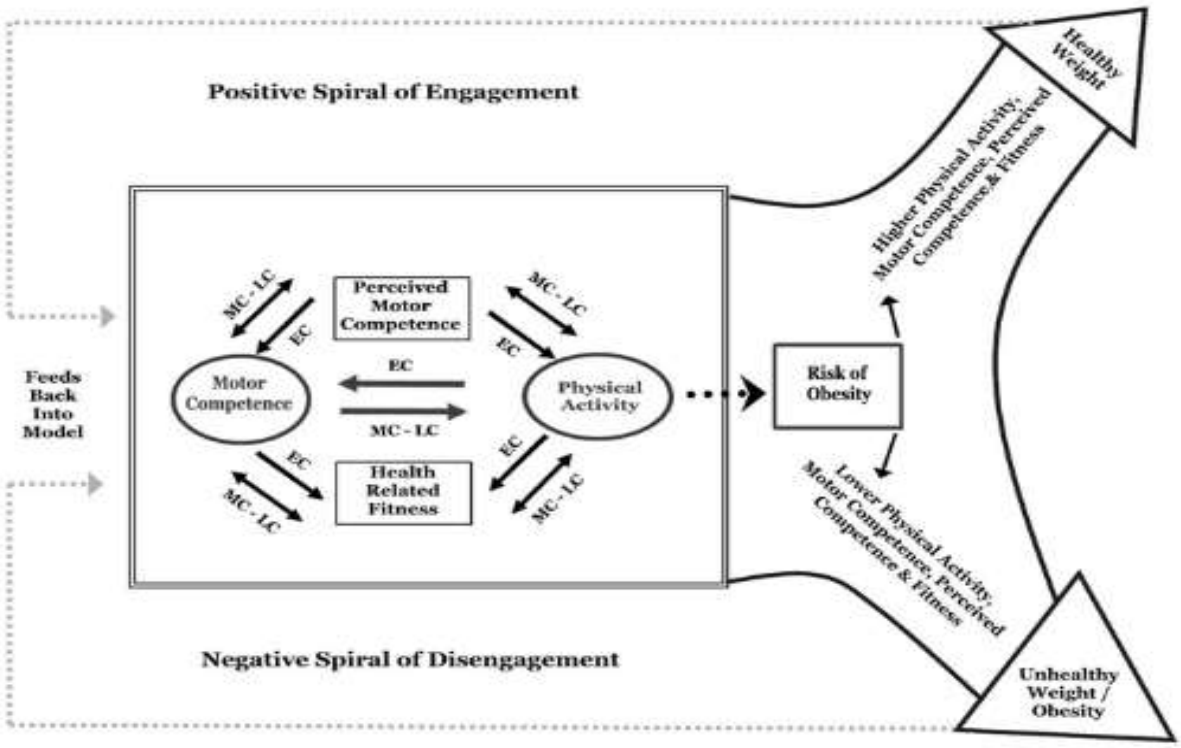

Figure 4.1: Developmental Model of Motor Competence by Stodden et al. (2008). EC = Early Childhood, MC = Middle Childhood, LC = Late Childhood.

higher levels of physical fitness are proposed to allow individuals sustain more time engaging in PA and opportunities to develop motor skills.

4.2.2 Project FLAME Original Iteration

Project FLAME began in 2016 to address Irish adolescents' low levels of movement proficiency across functional movement and fundamental movement skills. This original iteration of Project FLAME entailed two phases, the first being the collection of cross-sectional movement proficiency data within two schools, and the second being a 13-week, PE-based, non-

randomised controlled trial intervention in three schools (two intervention, one control from a suburban area of Cork, Ireland). Post-intervention testing revealed that the intervention was successful in developing MC amongst the intervention school populations in this convenience sample of adolescents. (Lester, 2020). Details of the original Project FLAME intervention and its four key components are detailed in Table 4.1.

The purpose of this study is to report the rationale for refining and developing an existing intervention entitled Project FLAME based on qualitative from the perspective of pre-service PE teachers (Lester, Belton, Duncan, & O'Brien, 2020, Under Review).

4.2.3 Project FLAME Original Iteration Diagrammatic Overview

Component	Key Points
PE Teachers/PE Lessons	- Deliberate practice of FMS and functional movements in PE class for 15-20 minutes of weekly PE lessons. - Teachers utilise movement cards including activities and teaching cues for each movement to reinforce learning with a focus on the use of external movement cues (for example, training the vertical jump by using the Mexican wave as a cue to develop arm propulsion). - Assessment for Learning (AfL); using questioning/observation/feedback to enhance learning) pedagogy was specifically encouraged. - Teachers allowed discretion in use of resource cards (i.e., could let students use them themselves or use them to instruct).
Kinaesthetic Classroom (KC) Breaks	- Targeted non-specialist PE teachers to become movement role models by showing 2-3-minute Kinaesthetic Classroom break YouTube videos in non-PE lessons. - KC break component ran concurrently with PE lesson component, reinforcing movement learning from PE lessons.
The Student	- Core focus of the project, all components designed to support student's development. - Movement tasks focussed on progression from basic to advanced movement performance.
Digital Component	- Resource cards include phone scannable Quick Response (QR) codes, which link to short video demonstrations of activity performances for the relevant skill. - KC breaks utilised the digital learning environment to bring movement into the classroom. - Students provided with handouts which had QR code links to the activities to practice at home.

Table 4.1: Overview of Key Components of the Original Project FLAME Intervention.

4.3 Methods

4.3.1 Data Collection

4.3.1.1 Participants and Recruitment

As part of the refining and further development of Project FLAME, invitations were sent to the PE departments of 9 urban second level schools in Cork, Ireland. Each of the targeted urban second-level schools were from areas of social and economic disadvantage, known as the Delivering Equality of Opportunity in Schools (DEIS) index (a programme to support schools with a high concentration of socioeconomic disadvantage; Department of Education and Skills, 2017).

The invitational letters sought to recruit pre-service and qualified PE teachers to participate in a free 'face-to-face' two-hour Project FLAME continuing professional development (CPD) workshop, followed by an evaluative 45-minute focus group (FG) research component discussion. In total, 6 pre-service PE teachers (4 males, 2 females) from 5 schools attended the CPD workshop and provided written consent to partake in the evaluative FG research element. The FG specifically sought to examine PE teachers' thoughts on Project FLAME following their CPD workshop, in addition to their views and experiences of adolescent MC levels. Participants were informed that they could withdraw consent at any time and that their input would be removed from the analysis. Prior to any data collection, ethical approval was attained from the Social Research Ethics Committee of University College Cork (Log Number 2018-169).

4.3.1.2 CPD Workshop

The Project FLAME CPD workshop was conducted in November 2018 and the purpose of the workshop was to expose the pre-service PE teachers to CPD training in the practical implementation of the Project FLAME intervention. Teacher training lessons are commonly utilised across school-based MC interventions (Belton, McCarren, et al., 2019; Chan et al., 2016) Previous research by Lander et al. (2016), which sought to assess the feasibility of an FMS assessment battery in PE also included FGs in order to examine teachers' perceptions of the test battery having used it in practice. The CPD workshop and FG took place in the evening time, lasted for 3 hours in total, and attendance was free of charge.

The CPD workshop was delivered by two Project FLAME researchers (who are qualified PE teachers) under the guidance of a lead researcher. A synopsis of the original Project FLAME intervention and a comprehensive overview of the Project FLAME manual and digital resource components were provided via PowerPoint presentation. The pre-service PE teachers received hands-on, practical demonstrations on how to utilise the Project FLAME resource manual in a PE setting (for example, where to find teaching cues and activity diagrams for a particular movement), and also how to use the digital QR code links to access Project FLAME activity demonstrations. This digital training is in line with PE-CPD research by Armour et al. (2017), who suggest that in future, digital technology operated by trained PE teachers, will be part of contemporary PE and should therefore form a part of effective PE-CPD programmes. The pre-service PE teachers were shown the resources in action by being involved directly in practical demonstrations of the resource in a

naturalistic, PE-like setting. Following a researcher example, the pre-service PE teachers worked in pairs and utilised the Project FLAME resources to plan and deliver their own Project FLAME movement activities.

4.3.1.3 Focus Group

The FG interview explored two discussion topics, evoking pre-service PE teachers' thoughts on Project FLAME following their receipt of the face-to-face CPD workshop, in addition to their general views and experiences of adolescent MC in Ireland. A sample of the FG interview questions are shown below in Table 2. FGs were used for both convenience for participants and data collectors and have been used previously in research in the area of MC. The FG was led by a member of the research team, with a second researcher taking field notes from the FG discussion and operating the recording devices. A semi-structured approach was adopted through the use of the pre-planned questions, as shown in Table 4.2, which is in accordance with previous FG protocol when collecting data with PE teachers (Lander et al., 2016). The FG was audio recorded using a dictaphone, and the resulting recording was transcribed verbatim prior to data analysis. Participant identities have been redacted from the data to ensure their anonymity.

Discussion Section Title	Sample Questions
1: Adolescent's Movement	How proficient do you feel adolescents in DEIS schools are in terms of their movement proficiency? What factors do you think are affecting adolescent movement proficiency? What do you feel is the difference between 'good' movement, and 'poor' movement?
2. Views on the Project FLAME Intervention	Do you feel that you would be able to administer the intervention without support? What practical issues do you feel could arise in the implementation of this intervention? What is your opinion on the technological/digital aspects of the intervention? Do you feel that the Project FLAME intervention would offer a suitable challenge for your students? What changes would you make to the resources?

Table 4.2: Focus Group Topics and Sample Questions.

4.3.1.4 Data Analysis

Data from the transcription of the FG were analysed using the thematic analysis method as outlined by Nowell et al. (2017) which generated themes from the data. Thematic analysis is a foundational method of qualitative analysis which is used to identify, analyse and report patterns in data (Braun & Clarke, 2006). While discussion points were used in the FG, inductive analysis formed the basis of this data analysis; this entails data-driven

thematic analysis which attempts to avoid fitting the data into any pre-existing researcher theories and minimise the impact of the researcher's biases (Braun & Clarke, 2006).

In order to elicit the 'teacher's voice' in terms of contributing to the refinement of the Project FLAME intervention in vivo coding was utilised as an analysis technique to emphasise the actual spoken words of the participants (Manning, 2017). To ensure trustworthiness and an accurate depiction of the data, a six-phase step-by-step approach to data analysis was utilised, as outlined by Nowell et al. (2017). This process involved: 1) data familiarisation; 2) initial code generation; 3) searching for themes; 4) reviewing themes; 5) defining and naming themes; and 6) producing the report. Direct quotations from participants were also utilised for objectivity, and to ensure accuracy between the participants' expressed views and the researcher's identified themes (Elo et al., 2014). Analysis was conducted by two investigators, as a means of compensating for lone-investigator deficits, and to enhance the quality of data inferences (Archibald, 2016).

4.4 Results

From this pre-service PE teacher FG data, several themes emerged in each discussion section. Figures 4.2 and 4.3 detail themes present in each discussion section, as identified in the data analysis from the FG data.

4.4.1 Discussion Topic 1: Teacher's Views on Adolescent MC Levels - Overview

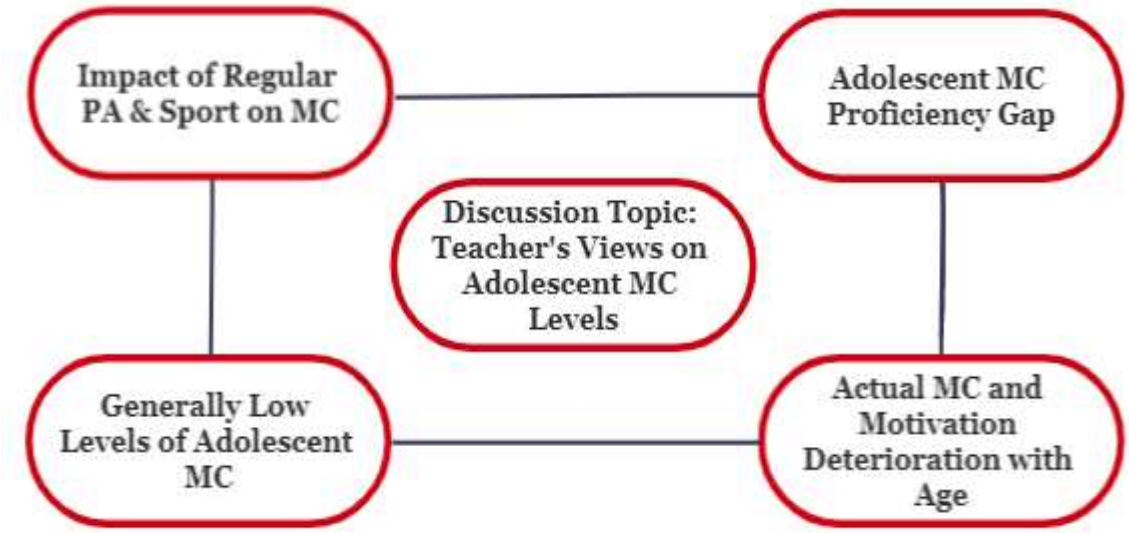

Figure 4.2: Teachers' Views on Adolescent Motor Competence Levels Thematic Diagram. MC = Motor Competence; PA = Physical Activity.

Through the FG data, pre-service PE teachers revealed their experiences and concerns regarding the MC development of their adolescent students in second-level school. Participants outlined the importance of regular PA and sport participation in the development and maintenance of adolescents' MC proficiency. Generally poor levels of MC were consistently reported by the DEIS school pre-service PE teachers, as well as an observed deterioration of MC with age. Participants identified that there was a growing gap between the MC proficiency of adolescents. The impact of motivation and student's poor perceptions of their own MC proficiency were also raised, however, the key issue for pre-service PE teachers throughout the discussion was the consistently low PA and sport participation levels of adolescents, and this void was viewed as a critical contributor to the poor levels of adolescent MC.

4.4.1.1 Theme 1: Impact of Regular PA and Sport on MC

A primary emergent theme from the FG data was that the pre-service PE teachers consistently noted that their students' MC proficiency was heavily linked to their engagement in PA and sport outside of the weekly allocated PE class time. The participants noted this clearly in the FG; *"The students who are playing sport and playing sport regularly are the ones who have good fundamental movement skills and functional movement",* and "*as a teacher, you would know the students and you can clearly see, when they are not moving well, that they haven't done sport. PE has been their only activity in three or four years*".

Other pre-service PE teachers suggested that sport participation outside of PE acted as a barrier to the declining levels of adolescent MC; "*I actually agree strongly with what [Participant Name] is saying there that anyone that is playing sport - there isn't a general decline*". Regular engagement in PA was also noted as a vital contributor to the development and maintenance of adolescent MC; *"it is the ones that are regularly active that are naturally enough better movers".* One participant identified that a lack of opportunity to be physically active outside of sport could be causing a decline of MC in female adolescents; "*a lot of girls aren't sporty, but they might have some interest in being active… I don't think there is an alternative there for them to remain physically active in a collective setting without playing sport… a lot of them aren't very active and (that's) why their movement ability decline* ". This recurring theme, as identified by all pre-service PE teachers highlights the importance of regular PA and sport participation for adolescent MC development, especially outside of timetabled PE.

4.4.1.2 Theme 2: General Low Levels of MC in Adolescents

Pre-service PE teachers noted that the levels of MC in their adolescent students were generally quite low across their classes. Participants mentioned their teaching experiences with students' low levels of MC several times; *"The standard (of MC) is low for the most part"; "For the most part, it (MC) is fairly poor"* and *"overall, the standard is quite low – lower than I was expecting."* One participant noted that an experienced colleague (educator with PE specialism) in school had recently remarked that their current students were notably less proficient movers than previous students of the school; *"the base level is very poor throughout all levels - even first year now – my co-op teacher says a lot of them would be very, very below average even from what she has seen in the DEIS school".*

4.4.1.3 Theme 3: Actual MC and Motivation Deterioration with Age

The theme of deteriorating levels of adolescent MC and motivation to move was prevalent in the FG data, with participants frequently noting a decline in the motor skill abilities of their students with age. It was suggested that the deterioration of motor skills takes place upon entering second-level schooling *"I would see with the young years that they aren't too bad… but I find with the older years that the movement skills with some students have deteriorated quite a lot and kind of seem to get worse as they get older".* One participant linked this decline to the aforementioned theme of the impact of sport and PA on MC stating, *" if you don't play sport, by second or third year, there is a rapid, rapid decline and by senior cycle they have very little ability*". Alongside the observed decline in actual MC proficiency with age, the issue of declining motivation levels with age was also raised as a potential cause of

movement proficiency deterioration; *"it is just the attitude towards movement being overall in a girls' school – even like first years it is quite good - but from second year on it just deteriorates rapidly – just the attitude towards movement let alone the movement itself."* This suggests that poor attitudes towards PA and movement can develop with age which may be inhibiting early adolescents' MC development, particularly in females.

4.4.1.4 Theme 4: MC Proficiency Gap in Adolescents

A common theme in the FG data was the pre-service PE teachers' observations of a MC proficiency gap between the highly proficient movers and their less skilled peers. One participant clearly articulated this *stating "The disparity between the student who is good at the movements and the student who is poor is huge".* This motor proficiency gap was also noted as being problematic for teaching; *"the difference between the weak and the strong girls is unbelievable… There is a huge differentiation issue".* It was also suggested that while MC levels in the DEIS school were generally poor, some students who actually engaged in sport were excellent movers and were exceptions to the rule*; "The majority would be below average and then you would have the one or two that are good at soccer or whatever and they are excellent but they are in the minority".*

4.4.2 Discussion Topic 2: Teacher's Views on Project FLAME - Overview

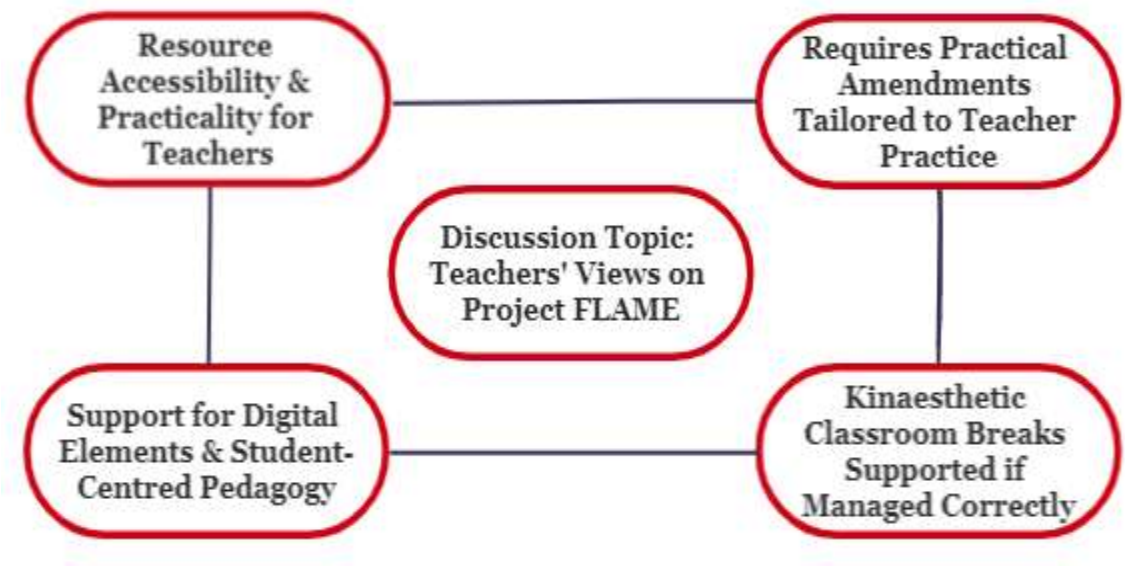

Figure 4.3: Teacher's Views on Project FLAME Thematic Diagram.

The FG discussion surrounding Project FLAME and its resources highlighted that pre-service PE teachers saw Project FLAME as a useful tool or facilitator for developing their teaching practice rather than as a didactic guide. This vital distinction outlines that the pre-service PE teachers would like to be in control of their own teaching and use their expertise to decide on their preferred pedagogy. Participants frequently returned to the practicality of the Project FLAME resources and how they would work with their students in their respective school environments. The participants generally supported the project and believed that the resources would be useful to enhance their PE teaching practice. Drawing on their experiences, the pre-service PE teachers did highlight potential alterations required to the Project FLAME resources, which they felt would enhance it as a pedagogical tool for developing adolescent MC. Participants also suggested that the resources could be used as an opportunity to assess students' motor skills and implemented as a digitally enhanced student-centred pedagogical tool.

4.4.2.1 Theme 1: Resource Accessibility and Practicality for Teacher Practice

Project FLAME and its resources were well regarded by the pre-service PE teachers as accessible and practically beneficial for supporting their teaching. On the Project FLAME activities, one participant noted that *"I think it is kind of a good base for a teacher to work off and then you just alter it accordingly then to meet the needs of the students*". This sentiment is reinforced later in the discussion with a participant adding that *"I can see clearly that I could use the resource. If I have to change it then I can but it will work well".* Participants noted that some activities could be too challenging and the basic levels of the resource activities could be perceived as *"static"* and *"didactic",* however other activities within Project FLAME were appropriate for their students; *"it is nearly too challenging. You couldn't do that for too long. I know my girls wouldn't be able to hold it (push-up) for that long and there are other ones like the squat jump that is perfect".* With regards to the intervention, one participant noted that the resources would be an adequate support for PE specialist teachers to implement the Project FLAME intervention *"I think any PE teacher worth their salt with that pack will be well able to. The diagrams and the codes – it is an excellent resource".*

Other participants believed that the Project FLAME MC development activities were appropriately progressive from the basic to more advanced skill practice difficulty, and offered scope for differentiation in the lesson; *"it goes from very basic to much advanced; so the progression is good I think"; "You could even have a group doing the basic one – even set it up as a circuit … going through each stage of it; so all of them are being challenged at some point… Just the fact that there are different levels of them. I think it would work*

that way". The pre-service PE teachers highlighted that the functional movement aspects of the project in particular may be difficult to include in their week-to-week lessons, suggesting they may be best included as warm-up or cool down activities in their teaching *"I don't know about doing it every week";* and *"Maybe… in like the warm up and cool down – not in the main body (of the lesson)".* One participant suggested that the activities of Project FLAME offered an opportunity for teachers to assess their students MC proficiency through progressive in-class developmental activities; *"even if it is in a game… you are still doing the skill and you can still be assessing them".*

4.4.2.2 Theme 2: Support for Digital Elements & Student-Centred Pedagogy

Pre-service PE teachers were broadly supportive of the digital elements of Project FLAME, most notably utilising the QR code links to activities within PE. Participants also highlighted how the project's resources, such as the external movement card cues and the digital QR code activity links could be used in a student-centred PE pedagogy environment; *"I think the (external cue card) would probably be better for the students themselves as well because it is more showing them the actual skill"* and; "*they come in, they set it up - they are the only ones with the technology - and they can run it. That would work really well with them… those that you can trust obviously".* The potential for digital literacy development through Project FLAME was also discussed in the FG, however, the overall practicality and pedagogical management remained an issue for the pre-service PE teachers; *"in PE class when they look up videos and they take to it really well so the digital literacy will definitely work… you have to set the rules very early on I think".*

4.4.2.3 Theme 3: Requires Practical Amendments Tailored to Teacher Practice

Several practical amendments to the Project FLAME resource were suggested in the FG by pre-service PE teachers, which they felt would make the intervention resources more practical as pedagogical tools. Basic suggestions included amending the opening index of the handbook to be clearer and numbering pages. Further to this, it was suggested that the handbook could be made more practical for PE teacher use if the QR code links to activities were included on the relevant activity diagram rather than on a separate page. This amendment was also suggested to make the handbook more accessible for student-centred pedagogical approaches *"Maybe if you had a QR code next to the games … then you have a QR code for the student and it makes it a lot more palatable for them so that, when they locate the skill, they can focus on one page and then when they are moving onto the game, they can focus on another page".* These suggestions highlight that the pre-service PE teachers' focus was on the practicality of the resource fitting within their professional practice and environment.

4.4.2.4 Theme 4: Kinaesthetic Classroom Breaks Supported if Managed Correctly

The Kinaesthetic Classroom breaks received support from pre-service PE teachers, however, reservations were again raised regarding their practicality. A participant shared an example of how movement-oriented classroom breaks had previously worked in their practice; *"I was in a room that was big enough that they could do that; and I found, after we had done it, they listened more to me".* Reservations were, however, expressed on the practicality of the KC breaks*; "I think the timing of it as well. I think if I was to do that at the start of my English class, the rest of my English class would be*

very tough… it would be good maybe half way through to do it" and*; "It comes back to the class that you have. If you know you have an already energetic class, the last class on a Friday, this is just going to add fire to the flame".* The participants did conversely note that the KC breaks could be beneficial to develop movement and learning, provided that these KC breaks were used appropriately to the situation and environment; *"if you have third class Monday morning, you know they are kind of academic and they are not quite energetic, it will get the movement and help them to be more confident in the class".* These sentiments support the use of KC breaks, depending on the ability of teachers in schools to adapt their practice to suit their unique teaching environments.

4.5 Discussion

This study aims to outline how the original Project FLAME intervention programme and its resources were refined and developed, via evidence-based thematic analysis to reflect the voices of pre-service PE teachers. The research contributes to a growing base of youth targeted intervention programmes aimed at improving adolescent MC levels in Ireland (Belton et al., 2014; McGrane et al., 2018). The results of this research have led to specific refinements and alterations being made to Project FLAME in advance of the Randomised Controlled Trial (RCT) phase of the study. The discussion begins with discussion topic 1 (Teacher's Views on Adolescent MC Levels) which provides evidence for the continuation of Project FLAME. The discussion continues to discuss topic 2 (Teacher's Views on Project FLAME) which outlines the evidence-based updates and resource developments, followed by

a discussion of how these changes were derived from to the major themes which emerged in the pre-service PE teacher FG.

4.5.1 The Case for MC Interventions in the PE Hall and the Classroom

In developing the future Project FLAME intervention, it is also important to establish if practitioners feel it is necessary. Through analysis of the FG data it appears that low levels of adolescent MC is observed by pre-service PE teachers in their practice. Throughout the FG, a consistent theme emerged from the participants which outlined their beliefs that MC is generally poor amongst the adolescent population in DEIS second-level schools. It is important to consider that all of these teachers were discussing students in DEIS schools given the evidence that socially disadvantaged children display significantly lower motor proficiency than socially advantaged children (Morley et al., 2015).

The data strongly identified that low PA and sport participation from adolescents was a contributing factor to such deficits in MC proficiency. Findings from 'The Irish Health Behaviour in School-aged Children (HBSC) Study' (2012) purported that Irish youths from lower social classes were more likely to report physical inactivity. Research in Ireland amongst the general population also validates this viewpoint, suggesting that PA levels amongst early Irish adolescents are low and have been declining in Ireland over the past decade (Woods et al., 2010, 2018). The low level of MC in Irish adolescents (Lester et al., 2017; O' Brien et al., 2016; O'Brien, Duncan, et al., 2018) is concerning, given the positive associations between high MC levels and PA (Lima et al., 2017), and PA guideline adherence and cardiorespiratory fitness (Woods et al., 2018).

FG participants noted that adolescents in their respective schools who engaged in PA and sport regularly seemed to have higher levels of MC, and that a substantial gap in MC proficiency seems to emerge between adolescents over time. Developing PA habits which are sustained across the lifespan is a goal of any PA-oriented project, and MC development is essential to this process (Hulteen et al., 2015; Stodden et al., 2008). Indeed, it is vital for children to attain a level of competency across skills, which enables successful participation across a wide range of PA (Clark, 2007; Clark & Metcalfe, 2002). MC is arguably one of the most essential components of PA participation for children and adolescents, and it is one which educators can contribute to improving (Seefeldt, 1980; Stodden et al., 2008). FG participant feedback suggests that there are currently too many adolescents being left behind in terms of developing the required MC levels, expected of their age. Effective interventions which sufficiently grow MC are therefore essential, as learned motor skills are cited as permanent (Gallahue et al., 2012; McMorris, 2014). While brief in duration, the future focus on classroom work, and the multi-component emphasis in Project FLAME has the potential to alleviate the movement deficiencies seen in adolescents (Belton, McCarren, et al., 2019; Tompsett et al., 2017).

Recent Irish studies have advocated for school-based interventions to arrest the declining levels of MC and improve PA levels in Irish youth (Farmer et al., 2017; Lester et al., 2017; McGrane et al., 2018; O'Brien, Duncan, et al., 2018). Targeted improvements of MC through PE lessons have been identified as a potentially valuable strategy to combat the observed plateau and decline of MC proficiency in adolescent youth entering second-level schooling (Behan

et al., 2019; Lester et al., 2017; O' Brien et al., 2016; Woods et al., 2018). Successful evidence-based interventions such as the Y-PATH intervention provide an effective Irish model given for comparison in the second-level school setting (O' Brien et al., 2013). The Y-PATH example has shown that the adoption of a whole school approach with multiple stakeholder involvement can lead to adolescent MC improvements (O' Brien et al., 2013).

'Move it Groove it', a primary school-based intervention in Australia, has also demonstrated effectiveness in the improvement of MC through modified PE lessons by generalist primary teachers. Eather et al. (2013) noted that generalist classroom teachers also play a key role in influencing PA behaviours in their students. Chen et al. (2014) outline that a concerted effort of PE teachers, classroom teachers, school administrators parents and community leaders to facilitate PA would remove some of the burden from PE teachers. The successful A+ FMS PE-based intervention emphasises supporting PE teachers in the implementation of Assessment for Learning (AfL) techniques (Chan et al., 2016, 2019). Specifically focussed curriculum-based PE (for example, FMS targeted lessons) have been demonstrated to improve MC in adolescents, which highlights the important role of PE lessons in improving MC (Lander, Morgan, Salmon, & Barnett, 2017; Lorås, 2020).

A primary theme from the FG was that the pre-service PE teachers desired a sense of autonomy in their professional practice when implementing the Project FLAME intervention. Teachers want to feel supported in their work, however, they do not want to feel overwhelmed by the additional pressure of an intervention, which is particularly prescient given the recent Irish findings of teacher stress and burnout towards the curriculum (MacPhail, Halbert, &

O'Neill, 2018; Scanlon, MacPhail, & Calderón, 2018). Trust in teachers, and recognition of their efforts is a key component to appropriately managing an intervention which teachers adopt (Lander, Eather, et al., 2017; Tompsett et al., 2017).

4.5.2 Alterations to Project FLAME

In this section, the details and alterations made to the Project FLAME intervention are rationalised based on the feedback derived from a representative sample of pre-service PE teachers. Table 4.3 in the discussion below details an overview of the alterations made to the various components and resources of the Project FLAME intervention and how they are specifically linked to the themes derived from the FG.

Component	Original Programme	Revised Amendments to Programme	FG Thematic Links & Rationale
Duration	13-Week PE intervention	Shortened to an 8-week PE intervention	FG: Resource Accessibility and Practicality for Teacher Practice More accessible for teachers and interventions of even 6-week duration have demonstrated effectiveness (Coker, 2018). Irish PE professional development service documents describe 8-week learning units for PE (Junior Cycle for Teachers, 2018).
QR Codes	QR codes linking to all PE-based activities on a separate QR code page for each movement.	QR codes moved to the activity pages in response to focus group. New QR codes also added for new activities.	FG: Support for Digital Element & Student-Centred Pedagogy. FG: Requires Practical Amendments Tailored to Teacher Practice Students and PE teachers could engage with materials easily.
Multi-Movement Activities	Not present in the original programme content.	New activity videos to develop multiple skills and patterns through one PE activity.	FG: Resource Accessibility and Practicality for Teacher Practice Multi-movement activities promote broad MC development while addressing issue of the lack of time to include both FMS and functional movements in PE time.
Kinaesthetic Classroom Break	Videos of research team instructing and performing different movements in class to promote skill acquisition and PA. Distributed by email and WhatsApp.	Retained and increased visibility in the handbook by creating an introduction to the KC class breaks section and creation of KC Classroom QR codes compiled together in the handbook.	FG: Kinaesthetic Classroom Breaks Supported if Managed Correctly Introduction section and collation of KC QR codes into one handbook section allows teachers to employ the KC breaks more easily and put QR codes to put in each classroom to KC enable the room for all teachers.
Activity Videos	Videos of individual and team activities to promote skill development with QR code links to videos on separate page.	New videos and QR codes added. Improved accessibility with QR codes next to the relevant activity in the handbook.	FG: Support for Digital Elements & Student-Centred Pedagogy FG: Requires Practical Amendments Tailored to Teacher Practice Utilises video-modelling to promote skill growth and nurturing.
Activity Module Planner (Handbook Index)	*Not present in the original programme content.*	A new facet prompted by FG and collective thinking of research design team. A guidebook showing how Project FLAME effectively interlinks with the Irish PE Curriculum content, as well as the inclusion of a table of contents.	FG: Requires Practical Amendments Tailored to Teacher Practice Given time constraints it allows teachers to adopt Project FLAME into current practice more easily.
Weekly Topic Breakdown	Presented at teacher training for 13-week Intervention	Provision of a potential timeline for the specific movements to be incorporated into PE lessons. Amended to fit new intervention duration	FG: Resource Accessibility & Practicality for Teacher Practice Allows for easier teacher adoption of the intervention by providing them with structure and guidance to maintain the intervention week on week.

Table 4.3: Amended Project FLAME Components and Resources with Rationale for Amendments. FG denotes which focus group theme(s) fostered this change.

4.5.2.1 Practitioner's Resource Handbook

Following the FG with pre-service PE teachers, several alterations were made to the project's resource handbook. Based on the feedback of the participants, the 'Practitioner's Resource Handbook' (See Appendix D) was significantly revised and updated to be more accessible for teachers to use prior to the commencement of PE lessons. Given the participants' broad support for the project resources, the initial handbook structure was retained. Specifically, all 17 movements still have their own 'activity' page, containing diagrams and explanations of activities to develop the movement as well as an 'external visual cues' page which outlines the key teaching points required to effectively improve each movement. The external cue element of Project FLAME is a novel and effective way of developing skills in young children and athletes (Abdollahipour, Palomo Nieto, Psotta, & Wulf, 2017; Pascua, Wulf, & Lewthwaite, 2015). An external teaching cue is one that focuses less on the inner mechanics (i.e. knee flexed at 90 degrees), and relates more to the effect (i.e. act like you are balancing a cup of tea on your knee, try not to spill it!) or outcome of the movement (Wulf, 2013). Motor skill performances in throwing, kicking, and balance have been improved in children and adolescents through an external cue focus (Abdollahipour et al., 2017; Wulf, 2013). FG participants suggested that the 'external movement cues' on the handbook may be beneficial for use through a student-centred pedagogical approach.

Based directly on feedback from the practising pre-service PE teachers, the 'activities' pages were altered to include QR code links to YouTube videos which demonstrate the activity on the relevant activity diagram. The revised Project FLAME handbook contains 76 basic and advanced activities across

the seventeen movements. An example of these QR code links is found below in Figure 4.4 which appears on the relevant diagram in the revised handbook. QR codes can be scanned by most smartphone cameras and will link directly to the relevant video for ease of access to the digital suite of resources within the manual.

Figure 4.4: QR Code Link to a Project FLAME PE Activity which Develops the Catch Skill.

In the FG, pre-service PE teachers identified that practical changes to the index of the handbook would make it more accessible. The practicality and accessibility of the resources was a recurring theme, with participants citing concerns about how some activities could be included within their lessons. In order to address these issues, the research team designed a 'Relevant Activities' table for the handbook introduction, and clearly specified which movements could fit within commonly practiced PE activities (for example, the catch movement fits within a basketball focused lesson). Although not explicitly mentioned in the FG, relevant sports and activities associated within the specific movement were also listed on the 'external movement cue' cards for each of the 17 movements. This update served the intended purpose of allowing practising PE teachers to include Project FLAME activities seamlessly into their lessons, under the theme of resource accessibility and practicality for teacher practice. An updated table of contents was also

included, alongside a brief introduction section, detailing practitioner use of the resource (for example, scanning QR codes and teaching the external cues through activities).

The digital elements of Project FLAME, such as the QR code links received support from the pre-service PE teachers in the FG. Digital learning and the use of technology is repeatedly noted in Irish curricular documents (Department of Education and Skills, 2015; National Council for Curriculum and Assessment; & Department of Education and Skills, 2016). Considering this, as well as feedback from the FG participants, the handbook's QR code links were made more accessible by placing them on their relevant activity diagrams in the handbook, thus allowing teachers to share these activity links with pupils for use in class or at home. Project FLAME's use of QR code videos of activities reflects a growing trend in health research towards digital or 'e-health' interventions. These digital interventions often utilise 'video-modelling' (i.e. using a recorded or live video performance of a skill and presenting it on a screen) to connect with study participants (Bulca, Ozdurak, & Demirhan, 2020; Obrusnikova & Cavalier, 2018). Digital interventions have previously demonstrated some degree of success in research. For example, a sample of 20 adolescents improved their functional movement capacity when supervised through digital videoconferencing sessions three times a week (Nourse et al., 2015). Additionally, digital video-modelling sessions have proven effective in growing locomotor skills in young childhood populations (N = 442) across Turkey and Bulgaria (Bulca et al., 2020).

4.5.2.2 Kinaesthetic Classroom

Having received encouraging feedback from the pre-service PE teachers in the FG, QR codes for the novel KC breaks were included in the new Project FLAME handbook to maintain a whole school movement culture focus, involving classroom teachers in addition to PE teachers. Involving classroom teachers in Project FLAME drew on the successful Youth Physical Activity Towards Health (Y-PATH) intervention (Belton et al., 2014), which adopted a whole school approach and utilised classroom teachers as role models to influence students' attitudes towards PA promotion. Given the novelty of this teaching approach and that the resource is designed for classroom teacher use, a comprehensive introduction to the KC breaks is included in the updated handbook. The updated manual now boasts seven unique KC break activity videos collated on a single page, eliminating the need to contact teachers with separate hyperlinks. This also allows classrooms to display the QR code on the wall to KC enable them. An example of the KC 'Landing Technique' QR code link is available to scan below in Figure 4.5.

Figure 4.5: Project FLAME Kinaesthetic Classroom Example QR Code Link for Activity to Develop Landing Technique.

4.5.2.3 Rationale for Intervention Design Alterations

Feedback from the FG suggested that the pre-service PE teachers viewed the Project FLAME resources as a useful tool to aid their teaching, however, participants repeatedly asserted that they would prefer to make their own pedagogical decisions regarding the intervention's use in their PE lessons. Given the need to make the Project FLAME intervention more accessible for PE teachers, whilst also meeting the research and scholastic time constraints, the specific duration of the PE class component of the refined Project FLAME intervention was redesigned from an initial 13-week non-RCT, to a future 8-week RCT. Potential issues may arise with the shortening of the intervention timeline which will need to be assessed as longer duration interventions have been found to be preferrable via systematic review (Dudley et al., 2011). In the FG, it was discussed by participants that it could be difficult to include certain functional movement activities week after week, and for these reasons, an 8-week lesson template (detailing which movements could be focussed on each week) (See Appendix E) was included as part of the next intervention rollout, specifically to make the project more accessible and time efficient for teachers' planning. This proposed weekly lesson template shows how the movements could be included in 8-weeks, however, in order to respect the expertise of pedagogues and to ensure that these professionals will continue to have autonomy over their pedagogical practice in future scenarios, it is only suggested for use.

The original Project FLAME activities were designed to be conducted concurrently with students' regular PE classes, and it was recommended to PE teachers that the allocation of 15-20 minutes of their class time to Project

FLAME within a standard double teaching period (80 minutes) of PE would afford second-level pupils with sufficient MC opportunities in Ireland (National Council for Curriculum and Assessment, 2017). While the revised RCT research intervention design is being proposed to be made shorter in duration, there is consistent evidence in school-based research that improvements in both FMS and functional movements can be observed within interventions of 8 weeks or less across both childhood and adolescent populations (Akbari et al., 2009; Coker, 2018; Morgan et al., 2013; Wright et al., 2015).

Currently, there is no curricular policy document which requires the teaching of FMS or functional movement across primary or second-level schooling in Ireland (National Council for Curriculum and Assessment; Department of Education and Science, 1999; National Council for Curriculum and Assessment; & Department of Education and Skills, 2016). It is well documented that curricula has the potential to influence teaching policy, however, it would seem likely that the teaching of FMS and functional movement may not be prioritised by second-level teachers, given their existing PE curricular expectations (Woodside-Jiron, 2004). A professional development service for second-level PE teachers in Ireland has recommended that an 8-week duration is a standard length for a learning unit (Junior Cycle for Teachers, 2018), and this research supports the future 8-week duration of the intended RCT rollout for Project FLAME.

Teachers in second-level PE in Ireland currently operate a demanding and stressful position, as three new curricula have been launched in the past few years (National Council for Curriculum and Assessment; & Department of Education and Skills, 2016; National Council for Curriculum and Assessment;

Department of Education and Skills, 2017; National Council for Curriculum and Assessment, 2018). Providing teachers with a short and effective intervention is critical to managing their workload, while maintaining effective intervention ideals (Lai et al., 2014). Purposeful interventions, such as Project FLAME, entrust PE teachers with responsibility towards delivery. Taking inspiration from the successful Y-PATH intervention and incorporating the FG pre-service teacher feedback, this iteration of Project FLAME sought to avoid overburdening teachers with requirements outside the purview of the curriculum, instead offering Project FLAME as an additional resource facilitate their teaching practice (Belton, McCarren, et al., 2019). Understanding teachers' needs and the ancillary demands on their time within the school is also essential to ensure the provision of optimal conditions for intervention success (Lander, Eather, Morgan, Salmon, & Barnett, 2017; Tompsett et al., 2017).

4.5.3 COVID-19 and Project FLAME in Practice

Currently, PE and PA are facing complex and unforeseen challenges in the wake of the COVID-19 pandemic. Across countries, the closures of schools and public recreation facilities, in addition to movement restrictions have restricted PA and MC development opportunities in children and adolescent youth (Jukic et al., 2020; Lesser & Nienhuis, 2020). The psychological impact of quarantine is wide-ranging, substantial, and long-lasting (e.g. quarantined individuals experience; post-traumatic stress, confusion, anger; Brooks et al., 2020). Sprang and Silman (2013) suggested that quarantine impacts youths slightly more than their parents. In a most recent systematic review of PA interventions, Andermo et al. (2020) reported

that PA interventions can reduce anxiety, improve resilience, wellbeing, and positive mental health in youths. These findings highlight the critical importance of maintaining PA and movement for youth during the COVID-19 pandemic.

Pre-service PE teachers in the FG showed a broad support for the digital elements of the Project FLAME intervention. Digital intervention strategies have demonstrated some positive evidence in the research for improving MC in young people (Bulca et al., 2020; Nourse et al., 2015). PE and classroom education for the foreseeable future will more than likely require a blended learning approach. Programmes like Zoom or Microsoft Teams may be used as supplementary digital methods to provide students with quality learning experiences, in lieu of conventional classrooms (Çakır & Bichelmeyer, 2016; Hrastinski, 2019). The digital resources of Project FLAME, utilise minimal equipment, provide clear and simple external cues, and contain activities designed for personal and small group practice. All of these digital resources in Project FLAME exemplify the high standards envisioned for blended learning, which may be particularly apt during these unprecedented times (Gewin, 2020; Vlachopoulos, 2020). The shortened duration of the Project FLAME exercises has the potential to prove enticing and engaging for adolescents, while providing chances to grow students' MC levels. Project FLAME through its detailed and accessible handbook illustrates how PE may operate in the interim through a blended learning approach by sharing instructional cues, activities, and guidelines for students to remain engaged (Wulf, 2013; Wulf, Chiviacowsky, Schiller, & Ávila, 2010).

4.5.4 Strengths and Limitations

The strength of this study is that the refinement of Project FLAME has been informed by pre-service PE teachers experience of the CPD training and their experience of using the resources in practice. The inclusion of practising pre-service PE teacher's voices, and particularly professionals with experience of teaching adolescents from low socioeconomic backgrounds has positively assisted the research team in the design of the revised intervention handbook. An unintended positive consequence and strength of the project is that in light COVID-19 era, the easily accessible online suite of resources within Project FLAME offer opportunities for students to develop their MC and practice PA through numerous non-contact activities in a remote setting.

When the Project FLAME RCT intervention is introduced to PE teachers in the future, the brevity of the 8-week intervention trial may be a limitation of the study, although short duration adolescent MC interventions have previously demonstrated improvements in MC (Coker, 2018; Dexter, Renggli, May, & Larkins, 2020). An obvious limitation of this study is that the FG was made up entirely of pre-service PE teachers leaving an absence of more experienced PE teachers. This study is also limited by the low sample size and that the FG was not repeated. All participants came from a homogenous population of teachers in that they all taught in socioeconomically disadvantaged schools and so their experience may not be entirely representative of teachers' experience in general populations.

4.5.5 Future Directions

Through the current CPD rollout and the qualitative data analysis of pre-service PE teachers, valuable practitioner insights have initiated the future

refinement of the Project FLAME resource alongside future research design. Given that the previous Project FLAME intervention trial evaluation was part of a non-RCT research study design, the next progressive step in the development of Project FLAME will be the implementation of an RCT study, seeking to examine the efficacy of the intervention on a broader and more diverse sample. According to Moreira et al. (2012), RCT's are the apex of research design. The intended Project FLAME intervention RCT may also benefit from the inclusion of retention testing, in line with a previously successful FMS intervention programme with adolescent in Finland (Kalaja et al., 2012). Retention testing beyond simple pre and post intervention data collection may offer an insight into the long-term effects of the Project FLAME intervention.

4.6 Conclusion

This study aimed to report the evidence-based rationale for altering the newest iteration of the Project FLAME intervention for Irish adolescent youth. Driven by the voice of practising pre-service PE specialist teachers, the revised Project FLAME research design presents a modern, relevant, and targeted whole-school approach to establishing an ecologically sound and effective MC intervention. Though unforeseen, the development of Project FLAME's innovative digital student-centred strategies offers a potential avenue for PE teachers to refine their pedagogy, while meeting the COVID-19 education protocol. These COVID-19 challenges have also created opportunities for engaging digital learners in the 21st century, a position which Project FLAME is equipped and poised to handle through its unique and

extensive digital platform, which supports evolving pedagogy to develop young learners' abilities.

Chapter V: Conclusion and Recommendations

5.1 Overview of Thesis

This Masters of Education by Research thesis sought to refine and develop the Project FLAME multi-component Physical Education (PE)-based movement oriented intervention for Irish adolescents (Lester, 2020). The Project FLAME intervention uniquely aims to develop adolescent Motor Competence (MC) across both the Fundamental Movement Skills (FMS) and functional movement constructs (as per the Functional Movement Screen™) thus expanding the conceptual framework of movement research as recommended by MC research both in Ireland and abroad (Hulteen et al., 2018; O'Brien, Duncan, et al., 2018).

This thesis, as an extension of Project FLAME's dataset, also expands upon the nascent yet ever-growing evidence base of adolescent FMS and FMS™ in Ireland across the world (Abraham et al., 2015; Anderson et al., 2015; Foweather, 2010; Lester et al., 2017; McGrane et al., 2017; O' Brien et al., 2016). As well as studying Irish adolescents' proficiency across both MC constructs of FMS and FMS™ singularly, this research project endeavoured to examine the quantitative evidence basis underlying Project FLAME's combination of both constructs. This research study aimed to work co-operatively with specialist PE teacher practitioners to ensure that the project was naturalistic to the PE environment and that PE teachers, as primary agents of change, had a voice in the refinements and amendments to Project FLAME (Kalaja et al., 2012; Lander et al., 2016).

Chapter I is an introductory chapter which details the background to research in this area of study and identified the aims and objectives of this research project as well as detailing various relevant research publications completed over the course of the degree.

Chapter II entails a critical analysis of literature relevant to this research study, including the areas of MC, Physical Activity (PA), FMS, functional movement, Perceived Motor Competence (PMC), Physical Literacy (PL) and MC/PA interventions. This chapter discusses and critically appraises the research landscape to offer a comprehensive overview of pertinent literature across these relevant areas. The key research findings which arose in the literature review were that adolescents demonstrate poor actual MC proficiency across both FMS and FMS™ functional movements. PA in youths also appears to be low and declining. MC and PA share a reciprocal relationship and are important contributors to health. Targeted and focussed PE-based MC/PA interventions which are built on a solid theoretical and evidence-based approach are needed. It is also important to consider the whole learner and factors external to the physiological dimension when attempting to develop actual MC as motivation and cognition are also important aspects to nurture in learners.

Chapter III (Paper 1) is a quantitative study of Irish adolescents' MC across both FMS and functional movement (N = 373; 178 female; mean age: 14.38 ± 0.86 years), examined via sex-based comparison. Further to addressing the objective of enhancing the Project FLAME's MC evidence base on an expanded and diversified sample population, this paper also examined if any association exists between adolescents' performances in the two MC

constructs upon which Project FLAME is built (i.e. FMS and functional movement). Actual MC data analysis revealed low levels of FMS and functional movement proficiency, high levels of dysfunctional movement, and significant sex-based differences across both FMS and functional movement. A moderate association between performance in the MC constructs of FMS and functional movement was also found.

Chapter IV (Paper 2) is a qualitative research paper which delineates the refinements and developments made to Project FLAME emerging from a focus group with pre-service PE specialist teachers from socioeconomically disadvantaged schools. Following the completion of a 'hands-on' Project FLAME CPD workshop, a focus group (N = 6; across 5 socioeconomically disadvantaged schools) was conducted which investigated: 1) the teachers' personal experiences of adolescent MC, and 2) the teachers perceptions of Project FLAME following the CPD workshop. Thematic analysis of the focus group data revealed that teachers believe that PA and sport participation are vital for MC, that MC seems to be declining as adolescents progress through school, and that a gap in MC proficiency seems to develop between adolescents. On Project FLAME, the teachers note that they see it as a potential facilitator for their pedagogical practice, with some practical amendments suggested in order to make Project FLAME more accessible and practical for teacher use. This paper provides a rationale for amendments, refinements, and developments made to Project FLAME from its original iteration based on the voice of pre-service PE specialist teachers.

5.2 Implications of the Research Study

5.2.1 Study I (Chapter III)

The purpose of this paper was to investigate current levels of FMS and functional movement proficiency, differentiated by sex, amongst Irish adolescents, and to examine if any associations between FMS and functional movement exist. No adolescent in the study demonstrated complete mastery of all FMS, despite research indicating that this is developmentally possible by the age of 6 (Gallahue et al., 2012). Functional movement proficiency was also found to be poor which is in line with previous research in Irish adolescent populations (Lester et al., 2017). Importantly, 91.7% of Irish adolescents studied displayed dysfunctional movement in at least one of the seven FMS™ movements. While sex-based dysfunctional movement results have been reported in a previous study by Coker (2018), to the author's knowledge, this is the first study in the field to report on the significance of sex-based differences across all seven FMS™ movements amongst adolescents. Further to this, the author has found only one other very recent paper (Wu et al., 2020) (pre-print and peer-review) which examines the association between process-based assessments FMS performance and performance of the FMS™. This has previously only been examined with product-based MC performances (Kramer et al., 2019; Silva et al., 2019).

The data derived from this study expands the growing evidence base of Project FLAME (Lester et al., 2017) and identifies empirical evidence of low actual MC in Irish adolescents across both FMS and functional movement, thus highlighting the need for interventions such as Project FLAME to ameliorate this dearth of ability. The finding of association between the MC

constructs of Project FLAME gives credence to the inclusion of this combination of MC constructs. Furthermore this study contributes to research in the emerging field of adolescent MC in Ireland (Bolger et al., 2018; Lester et al., 2017; McGrane et al., 2017; O' Brien et al., 2016) and globally (Anderson et al., 2015; Foweather, 2010; Hardy et al., 2013).

5.2.2 Study II (Chapter IV)

This qualitative study detailed the rationale for refinements and developments made to Project FLAME based on the perceptions of pre-service PE specialist teachers following their attendance of a Project FLAME CPD workshop. Qualitative data collection was carried out via a FG discussion conducted with 6 pre-service PE teachers. This focussed on two primary discussion areas: 1) their perceptions/experiences of adolescent MC and 2) their perceptions of Project FLAME and the intervention resources. Mixed research methods in interventions are encouraged in the development of childhood and adolescent school-based PA interventions as they offer data outside of quantitative data (Vaquero-Solís, Gallego, Tapia-Serrano, Pulido, & Sánchez-Miguel, 2020), thus this paper's inclusion of qualitative methods strengthens this research in its efforts to refine and develop the Project FLAME intervention. While paper 1 highlighted the need for an intervention based on quantitative data, contributing to the development Project FLAME's evidence base, this paper addresses the issues of refinement and development of Project FLAME by listening to the voices of key agents of change.

Overall, the pre-service teachers' perceptions of their adolescent students' MC was that they are generally poor, which supports previous findings in Irish MC research (Lester et al., 2017; McGrane et al., 2017; O'

Brien, Belton, & Issartel, 2015b). It is worth noting that the participants were commenting on their experiences in socioeconomically disadvantaged schools and socioeconomically disadvantaged children display lower motor proficiency than socioeconomically advantaged children and report higher levels of inactivity (Morley et al., 2015; Nic Gabhainn et al., 2012) Despite this, the pre-service teachers' perceptions of adolescent MC bore striking resemblance to findings within research in the area of MC in the general population.

The teachers highlighted that regular PA and sport participation was vital in developing MC which has been theorised and empirically evidenced in research studies (Barnett et al., 2011; Lima et al., 2017; Stodden et al., 2008). Further to this, the teachers outlined their experiences of generally low MC levels in adolescents (Foweather, 2010; O'Brien, Duncan, et al., 2018), that MC proficiency seems to decline with age when they stop engaging in sport (Behan et al., 2019; Lester et al., 2017). They also noted that a progressively widening MC proficiency gap begins to appear in adolescents as they progress through maturation between highly and lowly skilled. This aligns with Stodden et al's (2008) assertion of a 'physical activity divide' between those of high and low MC as the reciprocal MC/PA relationship takes greater effect into adolescence. Beyond this study's implications for the necessity of Project FLAME, and its need for refinement and development, it demonstrates that MC research is somewhat aligning with teacher experience of adolescent MC.

Teacher feedback highlighted support for Project FLAME and its resources but also clearly outlined that the teachers wanted the intervention to fit in to their practice. Based on the FG feedback outlined in this study, several alterations have been made to Project FLAME and its resources in an

effort to make the project more accessible and practical for teachers' use. For example, the FG participants showed particular support for the digital elements of Project FLAME such as the QR code links to activity and KC videos, this feedback prompted a change to the handbook resource which made the QR code links more accessible and prominent in the refined iteration of handbook. Indeed, this feedback and subsequent feedback helped to highlight the digital elements of Project FLAME, such as the KC breaks, which Vaquero-Solís et al. (2020) purport to be the future of school-based PE interventions.

5.3 Strengths and Limitations

There are several strengths of the research which are worth noting:

- The use of mixed methodologies offers a more diverse dataset (Vaquero-Solís et al., 2020). Breaking the quantitative/qualitative research dichotomy, mixed methods research offers a pragmatic alternative which is useful when addressing the multi-faceted problems encountered in the social sciences by providing 'hard data' as well as accounting for the interests and needs of stakeholders (Doyle, Brady, & Byrne, 2009). Mixed methods can offer a more comprehensive or complete view of a research study and the triangulation of evidence from both methods can be corroborated to establish greater result validity (Bryman, 2006; Doyle et al., 2009; Greene, Caracelli, & Graham, 1989).
- The inclusion of the 'Teacher Voice' in this study draws on the expertise and experiences of these specialist stakeholders (and ultimate agents of change) to have their opinions heard and

reflected in the refinement and development of the project which they are so critically important in implementing. Consulting the specialist practitioners on the ground has long formed part of research which seeks to implement changes to pedagogical practice (Ha, Lee, Chan, & Sum, 2004; Lander et al., 2016).

- The use of in vivo coding and inductive analysis in the analysis of qualitative data ensures that the identified data, used to refine and develop Project FLAME, arises from the participants, rather than previously held researcher beliefs (Braun & Clarke, 2006; Manning, 2017).
- The large and diverse sample size in the quantitative analysis of Study 1 (N = 373; 178 females; 6 schools; 2 mixed-sex socioeconomically disadvantaged, 2 male-only, 2 female-only) contributes significantly to the MC evidence base of Project FLAME.
- The MC data collection process of this study followed Project FLAME's previously utilised (Lester et al., 2017) rigorous processes based on established MC data collection methods (Hume et al., 2008; Lander, Morgan, Salmon, Logan, & Barnett, 2017; O' Brien et al., 2016; O'Brien, Duncan, et al., 2018). This study also utilised established MC assessment measures across both the FMS (New South Wales Department of Education and Training, 2000; Ulrich, 1985, 2000) and functional movement constructs (Cook et al., 1998, 2006a, 2006b).

- This research breaks new ground in its deeper exploration of dysfunctional movement in adolescents which has only recently been considered (Coker, 2018; Mokha et al., 2016). This study is also forward thinking in its examination of the association of FMS & FMS™ which is in line with emerging broader conceptualisations of MC (Hulteen et al., 2018)

As a contrast to this study's strengths, it is also important to note the limitations of this research study:

- All data, both qualitative and quantitative was collected in the same urban/suburban region of Cork in the south of Ireland, therefore the results may not necessarily be reflective or generalisable across Ireland and beyond.
- In Study 1, given the novelty of research into dysfunctional FMS™ movement performance as well as the association between FMS and FMS™, the dearth of FMS™ research (particularly in general adolescent populations) makes it difficult to interpret the results of the study.
- An obvious limitation of Study 2 lies in its inclusion of a relatively small sample of 6 exclusively pre-service PE teachers in the FG. Fully qualified teachers may have offered alternative feedback rooted in their experience of teaching practice over time. These pre-service teachers were also all working in socioeconomically disadvantaged schools and therefore the data may not be generalisable across a more diverse general population.

- FG data was collected at one time point only and did not allow the teachers the opportunity to test the resources in a real PE environment.

5.4 Recommendations for Project FLAME

The data obtained in this research has led to the refinement and development of the Project FLAME intervention from its original iteration to its new updated state. Recommendations for the future of Project FLAME are as follows:

- Building on the previous non-randomised control trial in 3 schools (Lester, 2020), a randomised controlled trial (RCT) should be carried out utilising the refined Project FLAME to evaluate this new iterations effectiveness in improving adolescents' MC. RCT's are the pinnacle of programme evaluation and as such, to ensure the efficacy of Project FLAME, it should undergo this scrutiny (R. F. C. Moreira et al., 2012). This evaluation would also benefit from the inclusion of at least three time points; pre-intervention, post-intervention, and a retention test to examine if the intervention has any long-term effects on skill (Kalaja et al., 2012).
- Following this RCT, a comparative analysis of results should be conducted between the original Project FLAME intervention and the new iteration to examine if the refinements and developments made to the intervention and its resources were effective (for example, shortening the intervention duration).

Results from this analysis should inform the development of a third, even more sophisticated Project FLAME iteration.

- Community Based interventions have demonstrated some success in developing adolescent MC (Morgan et al., 2013). Project FLAME should look towards expanding into the community sport setting to increase the impact and scope of the intervention.
- The continuation of the mixed methods approach is suggested to evaluate how stakeholders perceive Project FLAME. An examination of teachers' and students' experiences of Project FLAME is therefore recommended for the RCT iteration of Project FLAME (James et al., 2018; Lander et al., 2016).
- Expanding the research zone to regions outside of Cork City/suburbs is advised to examine if Project FLAME is generalisable in other areas of the country, such as rural areas.
- Project FLAME should continue to investigate PMC, how well it aligns with MC, and how the intervention is affecting PMC as it is an important mediating factor in the creation of positive or negative spirals of engagement (Bardid et al., 2016; Stodden et al., 2008).
- In light of the COVID-19 pandemic, a unique opportunity has arisen for Project FLAME, given government guidelines which highlight the need to avoid contact sports and to focus on skill development in PE lessons (Department of Education and Skills, 2020). To meet this need, and to expand the resources of the

intervention, the further expansion and development of activities to develop the 17 movement skills and patterns of Project FLAME should be developed, included, and evaluated in a third iteration of Project FLAME. It is recommended that the digital resources of Project FLAME of new activities should also be developed given the support which the digital resources received in the focus group and the potential future of online teaching and learning during COVID-19 (Basilaia & Kvavadze, 2020).

5.5 Conclusion

The aim of this research study was to refine and develop the Project FLAME intervention by expanding its evidence base and altering the intervention and its resources based on feedback from practising pre-service PE specialist teachers. This study built on the prior work on Project FLAME (Lester, 2020), in an attempt to improve the intervention and forward the case for a movement-oriented intervention to help Irish adolescents improve their movement abilities towards a more active and fulfilling life. The study has added to the growing field of research into adolescent MC in Ireland (Behan et al., 2019; Belton et al., 2014; Lester et al., 2017; O' Brien et al., 2016), and continues Project FLAME's unique combination of FMS and functional movement.

While this study has its limitations, the evidence-based refinements and developments made to Project FLAME, and the expansion of the evidence base across a larger and more diverse population sample, have positioned the study well to move onto its next stage of development, the RCT.

I began working on Project FLAME as an undergraduate aid for the early testing of the non-RCT intervention and being involved in this process inspired me to become involved in the project through further education and research. Though this work was challenging, I worked with the belief that this project will have a positive impact on young people's lives, and I wanted to further this cause. Throughout the course of my postgraduate studies, I have developed my planning, organisation, and critical thinking skills. Through the in-depth analysis of this particular area of study, I have attained very specific knowledge of this area, however, I have also developed generalisable and transferrable skills which I believe will serve me in my future work. These are skills which I did not envisage attaining at the beginning of the research process, however, upon reflection I see that I have developed in these areas significantly, which makes my learning experience all the more meaningful. I hope to use both my specific knowledge, as well as the generalisable skills which I learned through this process to advocate for and be directly involved in helping young people to improve their lives through the medium of movement.

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6.2 Appendices

6.2.1 Appendix A: Informed Consent for Principals

I. Project Title

Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'

II. Clarification of the purpose of the research

Culturally relevant research by O'Brien et al. (2016), found 'alarming' evidence that Irish adolescents entering post-primary school did not display competence across nine basic movement skills. Project FLAME was introduced, specifically to assess the levels of 1) fundamental and 2) functional movement at post-primary level, and to create a tailored movement-oriented intervention to ameliorate the life-limiting effects of movement deficiencies in Irish adolescents.

Van Beurden et al. (2002) suggest that children's Fundamental Movement Skill proficiency underpin active lifestyles. PE specialist teachers have been identified as a key factor in the successful implementation of interventions to help improve young people's motor development. (Belton et al. 2014).

In this element of the study, we hope to examine the viewpoints of both PE teachers and students pre and post participation in the Project FLAME intervention. It is hoped that this will allow us to gain valuable insights into participant's views on the intervention, so that we may develop the programme to be more practically workable and effective.

III. Confirmation of particular requirements as highlighted in the Plain Language Statement

Participant – please complete the following (Circle Yes or No for each question)

Have you read or had read to you the Plain Language Statement	*Yes/No*
Do you understand the information provided?	*Yes/No*
Have you had an opportunity to ask questions and discuss this study?	*Yes/No*
Have you received satisfactory answers to all your questions?	*Yes/No*
Are you aware that any interviews will be audio/video-taped?	*Yes/No*

Involvement in the research is completely voluntary. Participants may choose to withdraw from the study at any time. There shall be no penalty for withdrawing before all stages of the research project have been completed**.** Confidentiality is an important issue during data collection. Participant's identity, or other personal information, will not be revealed or published. Participants will be assigned an ID number, or a pseudonym, under which all personal information will be stored in a secure file and saved in password protected file in a computer at UCC. The investigators alone will have access to the data. Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions.

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project

Participant's Signature: _____

Name in Block Capitals: _____ **Date:** _____

6.2.2 Appendix B: Informed Consent for Teachers

INFORMATION SHEET

Purpose of the Study. As part of the requirements for the Master by Research degree at UCC, I have to carry out a research study. The study is concerned with evaluating the effectiveness of and developing the Project FLAME (Fundamental and Functional Literacy for Activity and Movement Efficiency) intervention on motor competence development in adolescents.

What will the study involve? The study will involve taking part in two focus groups with approximately 5 PE specialist teacher participants. The focus groups will discuss the topics of motor competence and the Project FLAME intervention. These focus groups will take approximately 20 minutes on each occasion.

Why have you been asked to take part?

You have been asked to take part in this focus group because your school has been selected to take part in the Project FLAME intervention and you are a PE specialist teacher.

Do you have to take part?

No, you are under no obligation to take part in the study. Participation is voluntary. If you would like to take part in the study, you must sign and return the consent form overleaf. If you agree to participate but change your mind before the study begins, you will be able to withdraw without giving any reason. If you have taken part in the study but would like to withdraw your information, you will have up to two weeks after the focus group takes place to do so.

If a participant wishes to withdraw, all efforts will be made to extract their individual comments. However, it can be difficult to identify specific individual's comments on an audio-recording and also can be difficult to disentangle the comments of one person from the overall group dynamic.

Will your participation in the study be kept confidential?

Yes. Confidentiality is an important issue during data collection. Participant's identity, or other personal information, will not be revealed or published. Participants will be assigned an ID number, or a pseudonym, under which Due to the group discussion nature of a focus group, it will not be possible to ensure that other participants will keep information they hear confidential, however this will be explicitly discouraged in the focus group meeting.

What will happen to the information which you give?

All personal information will be stored in a secure file and saved in password protected file in a computer at UCC. The investigators alone will have access to the data. Confidentiality of information provided can only be protected within the limitations of the law. It is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions. On completion of the project, data will be retained for minimum of a further ten years and then destroyed as specified by the UCC research guidelines.

What will happen to the results?

The results obtained will be presented in my thesis. They will be seen by my supervisor, a second marker and the external examiner. The thesis may be read by future students on the course. The study may also be published in research journals.

What are the possible disadvantages of taking part?

I don't envisage any negative consequences for you in taking part.

What if there is a problem?

While there are no negative consequences of taking part in the study envisaged, if a participant has any problem arising from taking part in the study you can contact the UCC Office of the Vice President for Research & Innovation, 4th Floor Block E, Food Science Building, UCC.

Tel: 021-4903501 Email: uccresearch@ucc.ie.

Who has reviewed this study?

This study has been reviewed and approved by the Social Research Ethics Committee of University College Cork.

Any further queries? If you need any further information, you can contact either:

Mr. Brian Donovan	***OR***	*Dr. Wesley O'Brien*
087–6910626		*021-4902319*
114321861@umail.ucc.ie		*wesley.obrien@ucc.ie*

If you agree to take part in the study, please sign the consent form overleaf.

CONSENT FORM

I……agree to participate in Mr. Brian Donovan's research study.

The purpose and nature of the study has been explained to me in writing.

I am participating voluntarily.

I give permission for the focus group with Mr. Brian Donovan to be audio-recorded.

I understand that I can withdraw from the study, without repercussions, at any time, whether before it starts or while I am participating.

I understand that I can withdraw permission to use the data within two weeks of the focus group, in which case the material will be deleted.

I will respect the confidentiality of other members of the focus group.

I understand that anonymity will be ensured in the write-up by disguising my identity.

I understand that disguised extracts from my interview may be quoted in the thesis and any subsequent publications if I give permission below:

(Please tick one box:)

I agree to quotation/publication of extracts from my interview ☐

I do not agree to quotation/publication of extracts from my interview ☐

Participant's Signature: ……. PRINT: …….

Date: …….

6.2.3 Appendix C: Informed Consent for Parents and Assent for Children

Project FLAME Information Sheet

Sports Studies & Physical Education

UCC

7th January 2019

Dear Parent/Guardian,

Please find overleaf an informed consent form for your child's participation in a movement study entitled 'Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'. This study is being carried out by University College Cork in your child's school. The study aims to gather information on the movement vocabulary and physical activity levels of students in the school and develop a plan to help improve these levels, and then to assess whether or not activity levels have been improved.

In order for your child to participate in this study, please read the attached form. If you do not wish your child to be involved, then you need to take no further action. If you DO wish your child to participate in the study, then I kindly request that both you and your child sign and return Option 2 at the bottom of the form.

Thank you for your time.

Yours sincerely,

Wesley O' Brien

Wesley O' Brien. Ph.D.

Principal investigator

Informed Consent Form

Project Title: Project FLAME – 'Fundamental and Functional Literacy for Activity and Movement Efficiency'

Investigators: Dr. Wesley O' Brien, Mr. Brian Donovan and Mr Conor Philpott.

Introduction to the study:

The ability to move with fundamental and functional competence has been shown to be extremely beneficial to youth in enabling them to move well and move often and is a key

determining factor in physical activity participation. In order to develop effective physical activity programmes for your (child's) age group, it is important that researchers understand the factors that influences adolescents in Ireland to become and remain active.

This is what will happen during the research project:

- Your child may complete a physical activity and movement-based questionnaire. This questionnaire will be filled out in class with the help of the class teacher and Mr. Conor Philpott.
    - Your child may have their height and weight measured.
- Your child may be recorded using a video camera in PE class to measure how well they can:
    - run; horizontal jump; strike; stationary dribble; skip; vertical jump; static balance; catch; kick and; overhand throw.
- Your child may be recorded using a video camera in PE class to assess the following:
    - deep squat; hurdle step; in-line lunge; shoulder mobility; active straight leg raise; trunk stability push-up and; rotary stability test.

A small subset of students will be selected to take part in two focus groups based on their experiences of movement and the Project FLAME programme before and after taking part in the project for the purpose of improving the project by listening to young people's experiences. If you would like your child to be eligible to take part in these focus groups, please tick the following box:

☐

All information gathered will be treated in the strictest of confidence. To ensure this, your child's name will be removed from all data and replaced with an ID number. Only the researchers will know your child's ID number, and only the researchers will have access to the information.

Please read Option 1 and Option 2 below and complete as appropriate.

Option 1: Child to be removed from the study

I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I request that my child is **not** included in the study. I understand that my child will not be penalised in any way for doing this.

ACTION: No further action necessary. Please file this consent form for future reference.

<u>Option 2</u>: <u>Child to be included in the study</u>

I have read and understood the information in this form. I have read and explained the information in the form to my child. The researchers have answered my questions and concerns, and I have a copy of this consent form. I understand that all students, including my child, are included in this study.

ACTION: To advise the research team of your decision please sign and return this form to your child's PE

teacher for attention of Dr. Wesley O' Brien. Please use the envelope provided.

Parent/Guardian Signature: _____ Name in Block Capitals: _____

Child's Signature: _____ Child's Name in Block Capitals: _____

Date: _____

6.2.4 Appendix D: Project FLAME Practitioner's Handbook

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Project FLAME

Instructions

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Project FLAME

Project FLAME - How to Use the Resource Pack

This resource pack contains 17 movement skills patterns across a range of locomotor skills, object control skills, and functional movement patterns. The pack is comprised of one card for each of the seventeen movements, each card has two sides. The first page contains suggested activities to develop the skill, while the second page contains visual and written elements of the key cues associated with the skill and suggested activities and sports in which the skill is especially relevant.

Each card has a minimum of two activities for use in activity settings (e.g. PE Lessons or Coaching Contexts), which move from basic to more advanced progressions of the movement. The basic stage focuses on the essential elements of the skill which are practiced in a low-intensity paired or individual performances. The advanced progressions typically contain activities at a greater intensity and are suited to larger work in groups. The fundamental aim of this intervention is to increase movement proficiency from basic to advanced for all learners, in the interests of improving their physical competence and activity levels.

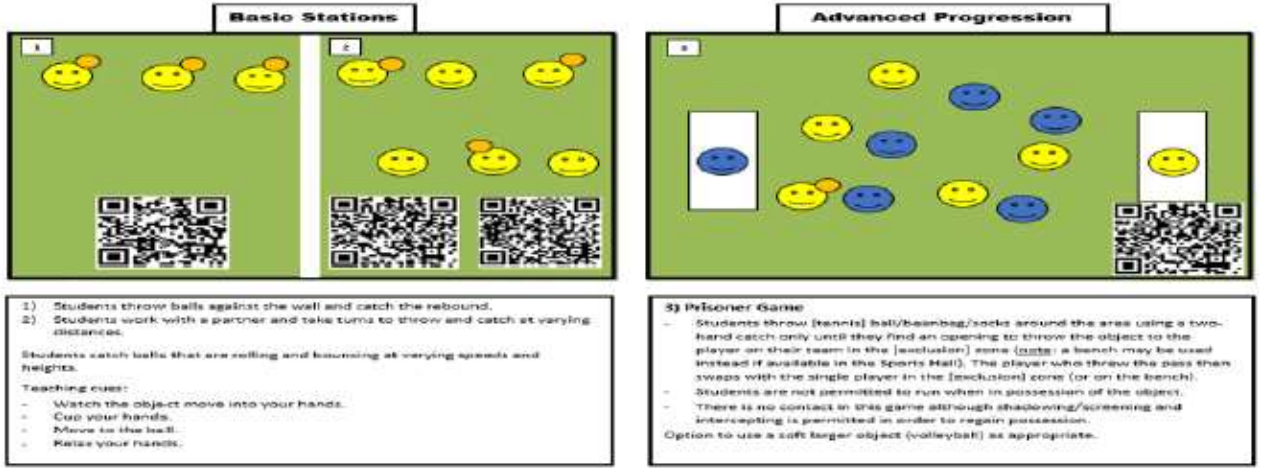
The ideas outlined in this resource pack are not a prescriptive programme to be administered, rather they are guidelines which can improve movement capabilities. The activities outlined serve as the medium through which the key skill cues can be taught, practiced, and developed. Alterations depending on environmental context and the pedagogical strategies of the instructor are welcomed.

Instructions

Project FLAME - How to Use the Resource Pack

Activities Page:

On the first page of the card, the activities page, sample diagrams of activities for the movement are provided. For each of the suggested activities, there is a QR code link to a YouTube video of the activity in practice. iPhones and iPads that have been updated to iOS 11 (or more recent updates) will allow your camera app to scan a QR code directly and bring you to the video. Android users may require a QR code reader from the Google Play store. In developing this pack, our research team utilised the Q.tk scanner developed by Q Inc, 2.3.135, which is freely available. A sample image of the Catch card's activity page with QR codes is shown below.



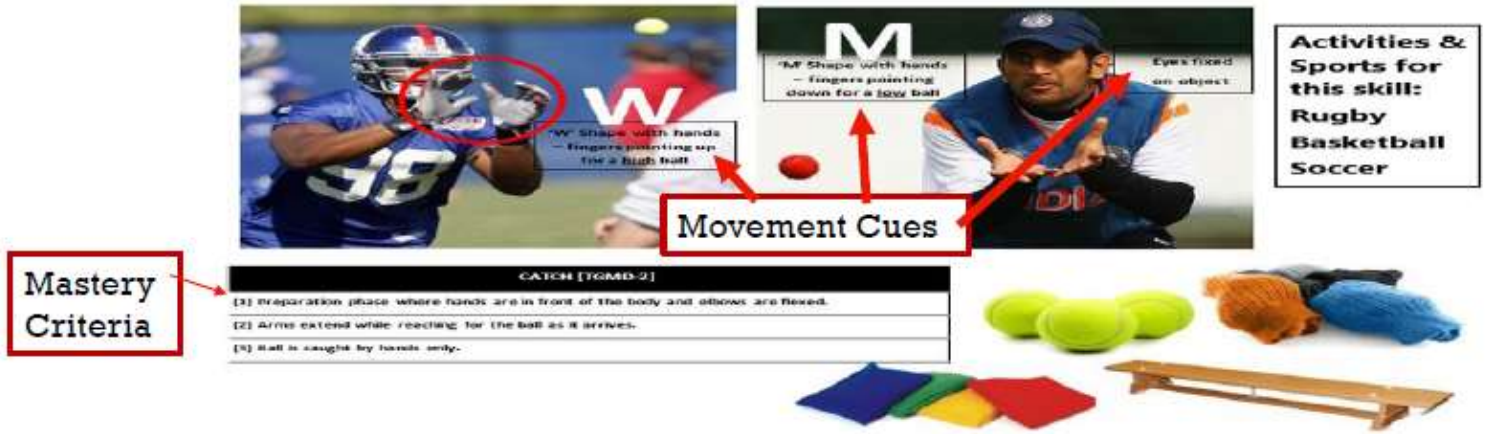
6

Instructions

Project FLAME - How to Use the Resource Pack

Movement Cues Page:

The second page on each card, the skill cues page, is pivotal to the project. As outlined earlier, our activities will be beneficial, but are not prescriptive. When teaching these skills, focusing on the key movement pointers is of critical importance to the development of the participant's movement proficiency. Both the written and visual elements serve to communicate these movement cues to both instructors and students. The criteria for mastering the movement are also outlined on the card. A sample of the Catch card, which also outlines sports and activities that relate to this movement is presented below.



Health Related Fitness Activities

Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V -Jump	H -Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Gymnastics						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Yoga & Pilates						✓					✓	✓	✓	✓		✓	✓
Strength & Conditioning						✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Flexibility /Mobility									✓	✓	✓	✓	✓	✓		✓	✓

Related Activities - Net/Divided Court Games

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Project FLAME

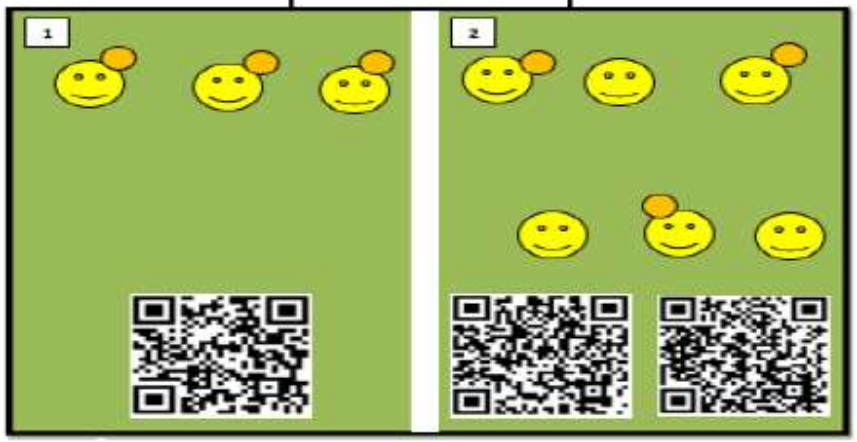
Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V-Jump	H-Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Badminton			✓			✓	✓		✓			✓		✓			✓
Volleyball	✓	✓			✓	✓	✓	✓	✓			✓		✓			
Tennis			✓	✓		✓	✓		✓			✓		✓			✓
Table Tennis			✓			✓					✓	✓		✓			
Spikeball	✓	✓				✓	✓	✓	✓		✓			✓			✓

Related Activities -Invasion Games

Activity	Catch	Throw	Strike	Kick	Dribble	Balance	Run	Skip	V -Jump	H -Jump	Deep Squat	In-Line Lunge	Active Straight Leg Raise	Shoulder Mobility	Hurdle Step	Trunk Stability Push-Up	Rotary Stability
Basketball	✓	✓			✓	✓	✓	✓	✓		✓			✓			
GAA	✓			✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	
Soccer	✓	✓		✓		✓	✓	✓	✓			✓	✓				
Rugby	✓			✓		✓	✓	✓	✓		✓		✓	✓		✓	✓
Olympic Handball	✓	✓			✓	✓	✓	✓	✓	✓				✓			✓
Ultimate Frisbee	✓	✓				✓	✓	✓	✓	✓				✓			✓
Hockey			✓			✓	✓	✓			✓	✓	✓	✓			✓

Catch

Basic Stations



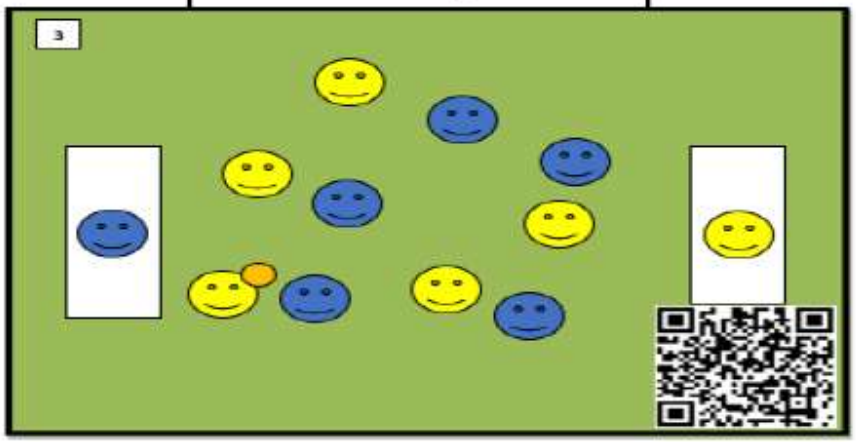
1) Students throw balls against the wall and catch the rebound.
2) Students work with a partner and take turns to throw and catch at varying distances.

Students catch balls that are rolling and bouncing at varying speeds and heights.

Teaching cues:

- Watch the object move into your hands.
- Cup your hands.
- Move to the ball.
- Relax your hands.

Advanced Progression



3) Prisoner Game

- Students throw [tennis] ball/beanbag/socks around the area using a two-hand catch only until they find an opening to throw the object to the player on their team in the [exclusion] zone (note: a bench may be used instead if available in the Sports Hall). The player who threw the pass then swaps with the single player in the [exclusion] zone (or on the bench).
- Students are not permitted to run when in possession of the object.
- There is no contact in this game although shadowing/screening and intercepting is permitted in order to regain possession.

Option to use a soft larger object (volleyball) as appropriate.

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Catch

Activities & Sports for this skill:

Rugby

Basketball

Soccer

CATCH [TGMD-2]
(1) Preparation phase where hands are in front of the body and elbows are flexed.
(2) Arms extend while reaching for the ball as it arrives.
(3) Ball is caught by hands only.

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Throw

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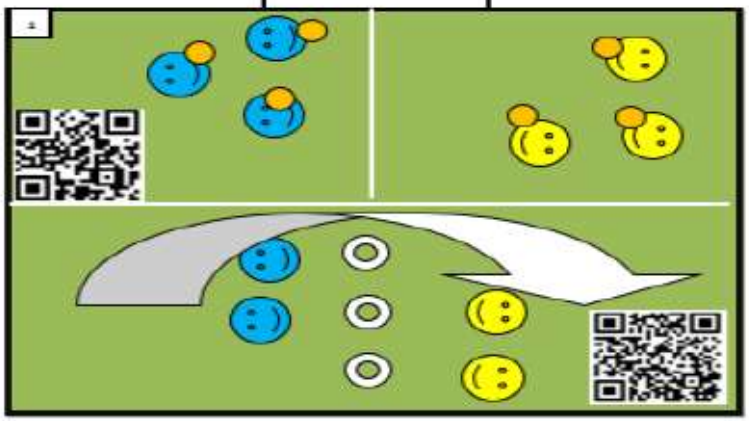
Project FLAME

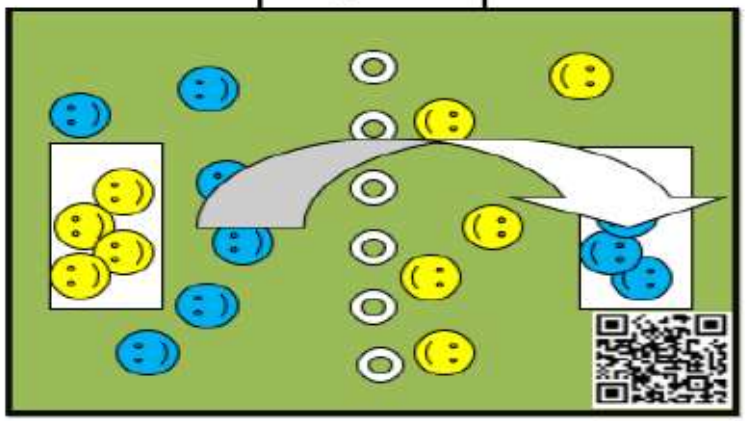
Basic Station



1) Students throw beanbag/socks/ball against a wall.
2) Students throw beanbag/socks/ball from one side to another for distance
- The speed and distance of the throw is determined by the follow-through.

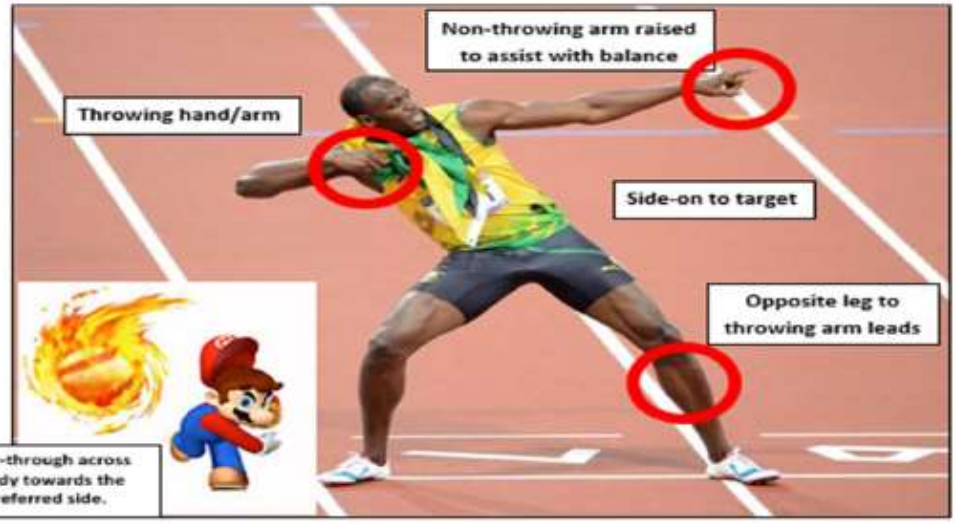
Explore the throw using a range of the following:
- experiment with different hip, shoulder and feet movements as they throw.
- stand facing towards the target, keeping their hips and feet still.
- stand side-on and rotate their shoulders but not their hips.
- stand side-on and rotate hips and shoulders.
- take a small step as they throw to transfer their body weight.
- identify which position is the most efficient for distance and speed.
- Have students practice the throw from a sitting and kneeling position (optional).

Progression



- Students throw beanbag/socks from one side to the other trying to reach a member of their own team on the opposite side. This will free them from the box and allow them to rejoin their team.
- Students on the opposing team are not allowed into the box.
- Students may however also throw beanbag/socks at a member of the opposing team (below the waist) similar to the game of dodgeball.
- If hit, that student will then join their teammates in the box on the opposite side.

Throw



THROW [TGMD-2]
(1) Wind-up is initiated with downward movement of hand/arm.
(2) Rotates hip and shoulder to a point where the non-throwing side faces the wall.
(3) Weight is transferred by stepping with the foot opposite the throwing hand.
(4) Follow-through with hand beyond ball release diagonally across the body towards the non-preferred side.

Activities and Sports for this Skill:

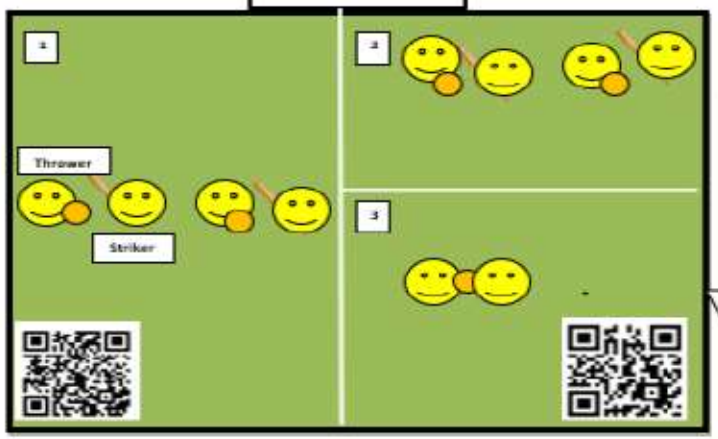
- Olympic Handball
- Rounders
- Basketball

Show me the Nike logo using your arms

The most successful slogan in the world – 'Just Do It'

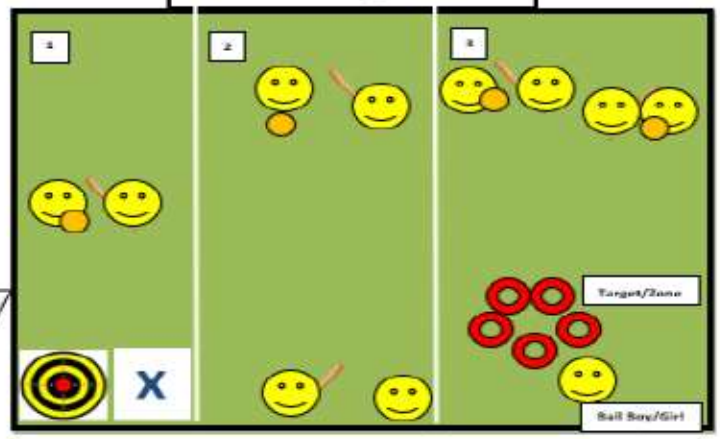
Strike

Basic Station



1) Strike the object as hard as possible at wall, partition or fence.
2) Strike the object as hard and as far as possible.
3) Partner Rotational Twists
   Explore the strike using a range of the following:
- swing with both arms bent.
- swing with both arms straight.
- make a 'half swing' with no follow-through.
- try a full swing and follow-through.
- -Work on swinging through the strike by passing to a partner, developing both sides in a twisting motion. (Activity 3)

Various Progressions



1) [Hall] Strike the object forcefully at a target placed on the wall.
2) [Field] Strike the object to a partner standing at a distance (i.e. to encourage forceful striking). The striker on one side is partnered with the catcher on the opposite side (who then becomes the thrower on that side) and swap roles.
3) [Field] Strike the object forcefully at a target/zone placed on the ground at a distance (note: the aim is to land the object in the target/zone rather than have the object roll/bounce into the target).

Strike

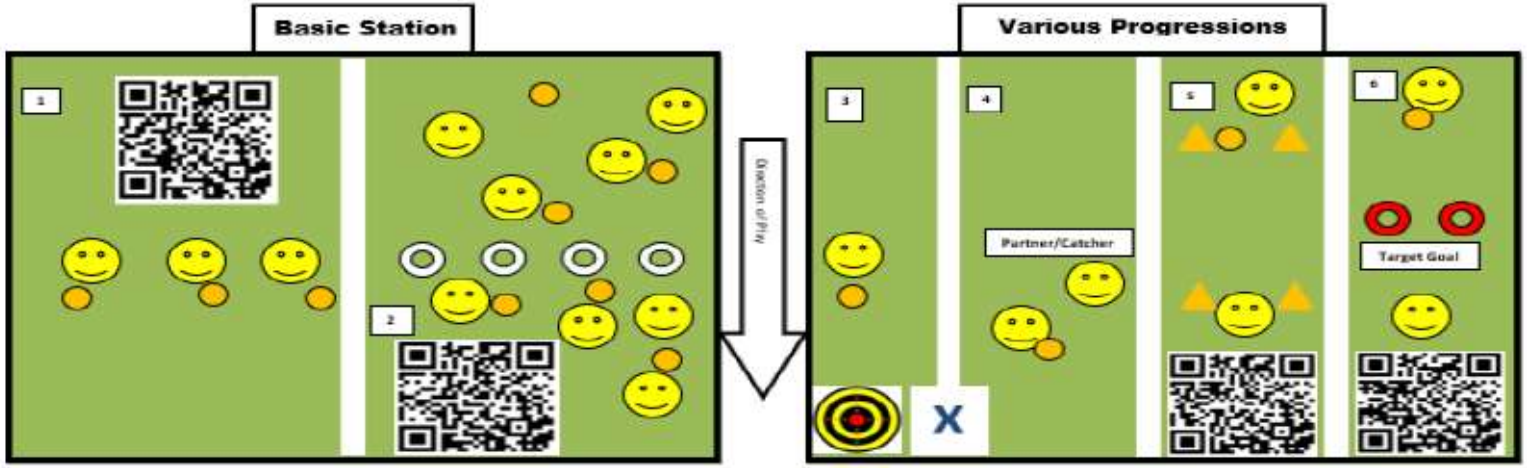
Activities and Sports for this Skill:

- Rounders
- Hurling
- Badminton

Ensure bats have a large surface area to facilitate successful attempts.
Use soft/larger objects to encourage forceful striking without the risk of injury.

STRIKE [TGMD-2]
(1) Dominant hand grips bat above non-dominant hand (as the bat is pointing up).
(2) Non-preferred side of body faces the imaginary thrower with feet shoulder width apart.
(3) Hip and shoulder rotate/turn during swing.
(4) Transfers body weight to front foot.
(5) Bat contacts ball.

Kick



1) Kick the ball as hard as possible at wall/partition or fence.

2) Kick the ball as hard and as far as possible from one side to the other. The aim is to kick the ball passed the group on the other side.

Explore the kick using a range of the following:
- approach the ball from directly behind and from an angle (i.e. from the side) to enable the kicking foot to follow through and touch the opposite hand.

3) [Hall] Kick the ball forcefully at a target placed on the wall.
4) [Hall] Kick the ball forcefully at the wall and attempt to land the rebound in the hands of a partner who cannot move their feet.

5) [Hall/Field] Kick the ball to partner's goal standing at a large distance apart (i.e. to encourage forceful kicking and accuracy as opposed to a short pass).

6) [Hall/Field] Kick the ball forcefully through a target goal on the ground at a distance

Kick

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Project FLAME

Use soft balls to encourage forceful kicking without risk of injury. These balls won't travel very far.

Place ball on top of cone to encourage kicking with instep or shoelaces

Fast forward on approach to ball

Kick foot to opposite hand on follow-through

KICK [TGMD-2]
(1) Rapid continuous approach to the ball.
(2) An elongated stride or leap immediately prior to ball contact.
(3) Non-kicking foot placed even with (to the side) or slightly behind the ball.
(4) Kicks ball with instep of preferred foot (shoelaces) or toe.

Activities and Sports for this Skill:

- Soccer
- Gaelic Football
- Rugby

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Dribble

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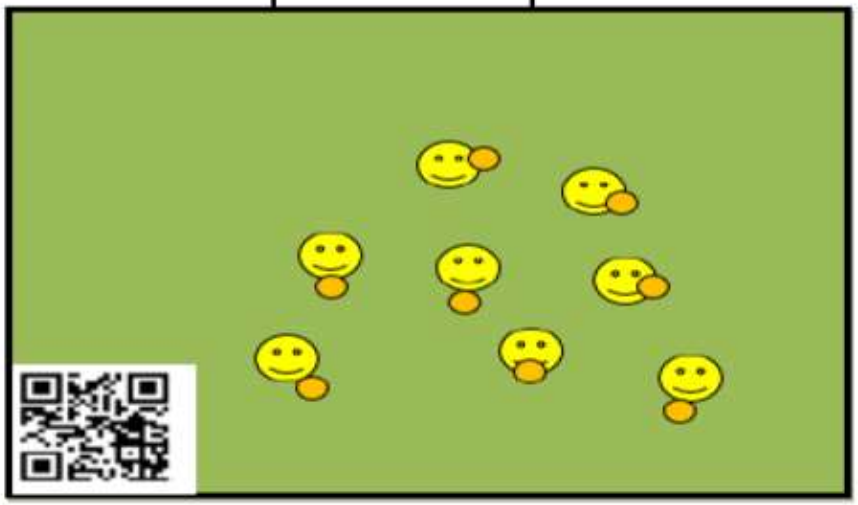
University College Cork, Ireland

Project FLAME

Basic Station

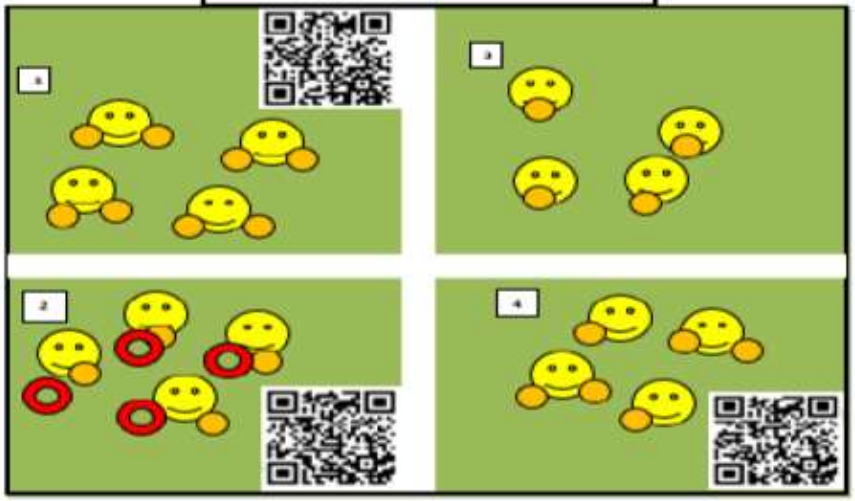


Basic Station Explanations:

Explore the dribble using a range of the following:

- What different parts of the hand can you use to dribble the ball?
- How soft can you dribble the ball or how hard?
- How low can you dribble the ball or how high?
- How close to the body can you dribble the ball or how wide?

Advanced Progressions



1) Dribble two balls at the same time.
2) Dribble around the area and each time a student comes to a cone they do a full circle around the cone while maintaining control of the ball.
3) King of the Ring: Each player dribbles a ball around the zone. The player must try to knock all other player's balls out of the zone while continuing to dribble and protect their own ball until they are the only remaining player.
4) Dribble the ball while sitting flat using one ball or two.

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Dribble

DRIBBLE [TGMD-2]
(1) Contacts ball with one hand at about waist level.
(2) Pushes ball with fingertips (not a slap).
(3) Ball contacts surface in front of or to the outside of foot on preferred side.
(4) Maintains control of ball for four bounces in a row without having to move the feet to retrieve it.

Activities & Sports for this skill:

-Basketball - Gaelic Football (Hop)

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Balance

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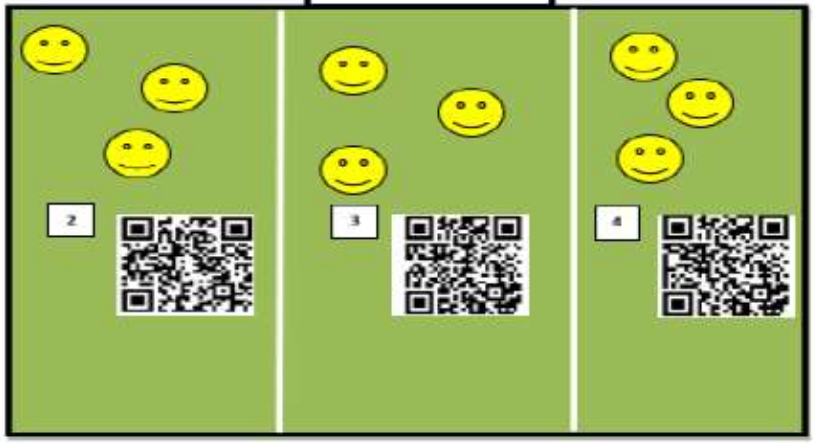
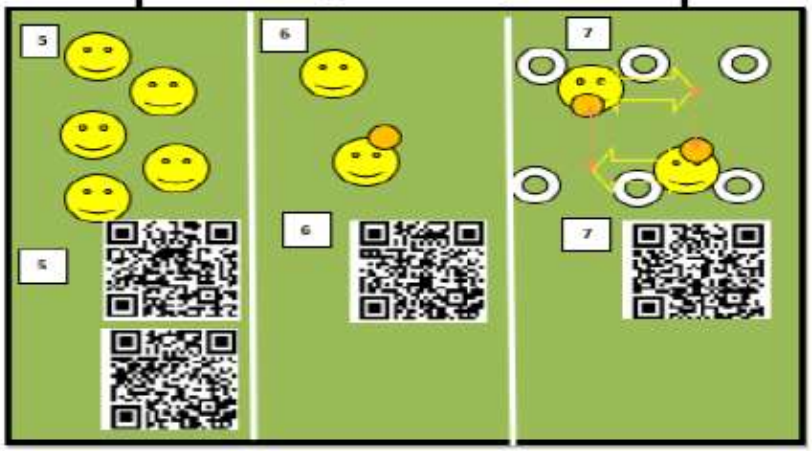
Basic



Challenge students to try the following activities with their eyes closed and/or on their non-preferred leg.

1) **Basic Balance. (Standing on one-foot alternating legs)**
2) **Balance and Arm Movements.**
3) **Balance and Object Control.**
4) **Balance and Twist.**

Various Dynamic Progressions



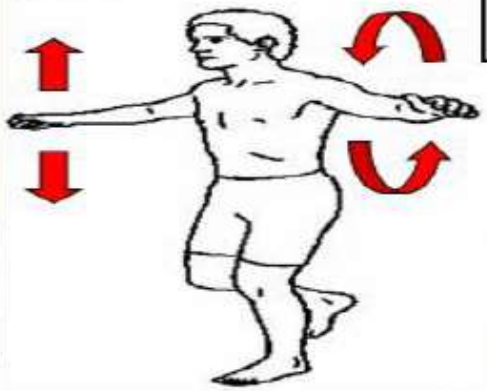
Challenge students to develop their ability to maintain or regain static balance from unstable positions including flight and while catching an object.

5) **Basic Lateral Bound with Balance.**
   Advanced Lateral Bound with Balance.
6) **Lateral Bound with Catch and Balance (Basic to Advanced).**
7) **Co-Operative Lateral Bound with Catch and Balance.**

Balance

Basic Balance

Maintain a stable and upright trunk by engaging the core while arms are working.



BALANCE [GET SKILLED: GET ACTIVE]
(1) Standing leg still, foot flat on the ground.
(2) Non-standing leg bent back behind at the knee, not touching the standing leg.
(3) Head stable, eyes focused forward.
(4) Body stable and upright.
(5) Arms stretched out wide at the sides with no excessive movements.

Activities & Sports for this skill:

Gymnastics & Dance, Team Games

Lateral Bound

Progress from a 'Basic' to an 'Advanced' Lateral Bound by increasing the height and/or distance while maintaining balance (single leg) on landing.

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Run

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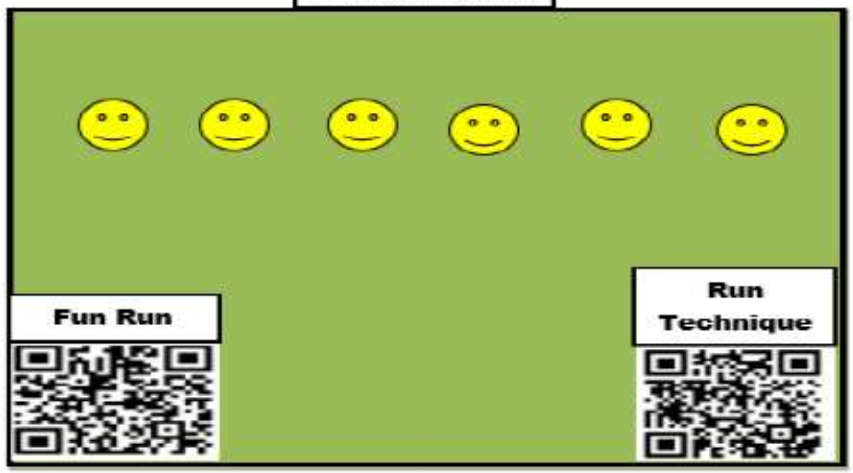
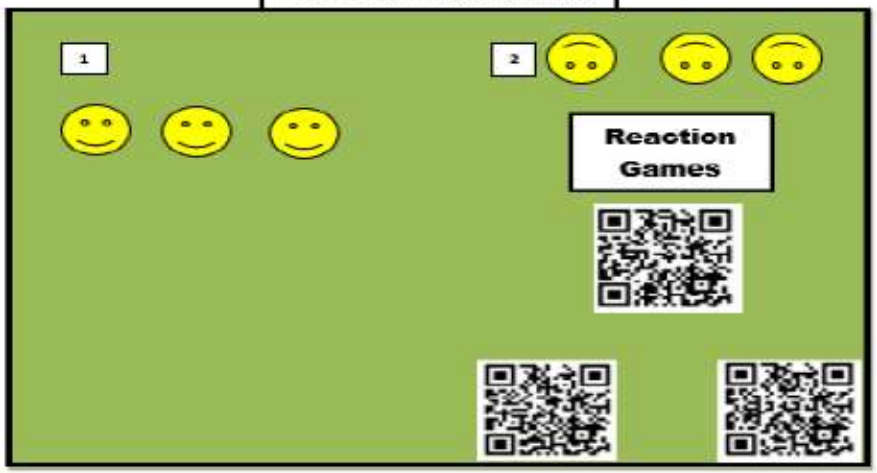
Basic Stations



- Run as fast as possible (sprint) for a distance of 10m – 20m.
- Students should land on the ball of their foot when sprinting.
- Run while focussing on specific body parts (legs, hands and head) as cued.

Various Progressions



1) Marching for a distance of 10m – 20m exaggerating a sprinting technique as cued in card overleaf.
2) **Wall Exchanges:** Students place both hands on the wall in front of them and adopt an exaggerated sprinting position facing the wall (i.e. one knee lifted with toes pointing up, chin facing forward, and on the ball of the standing foot). On the leader's call of 'go', students react and switch and hold in position for the next 'go'

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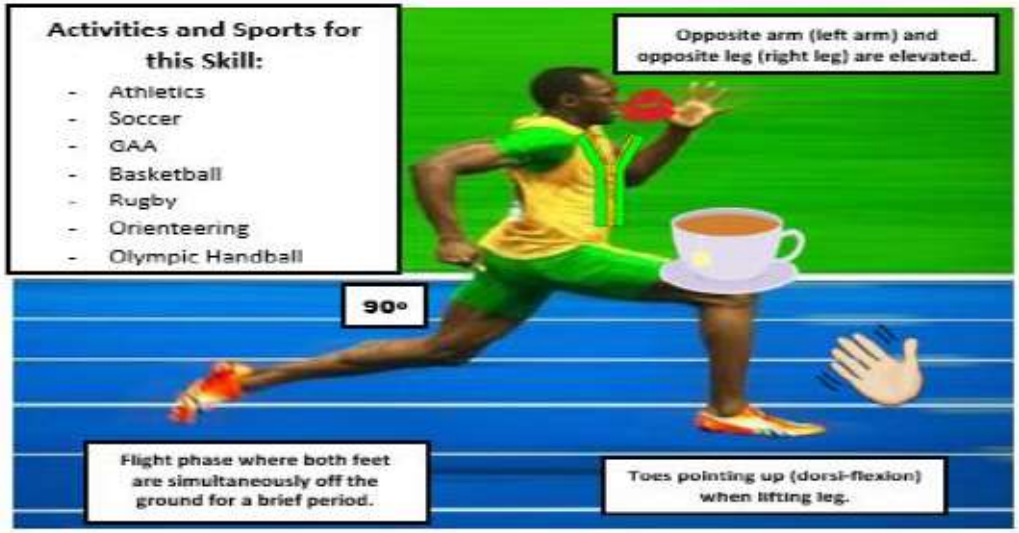
Run

Activities and Sports for this Skill:

- Athletics
- Soccer
- GAA
- Basketball
- Rugby
- Orienteering
- Olympic Handball



RUN [TGMD-2]
(1) Arms alternately moving in opposition to legs, elbows bent.
(2) Brief period where both feet are off the ground.
(3) Narrow foot placement landing on heel or toe.
(4) Non-standing leg bent approximately 90 degrees.

LEGS

'Cup of tea up on the knee'

'Hello toe'

HANDS

'Hip to lip don't cross the zip'

HEAD

'Sort the chin and you will win'

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Skip

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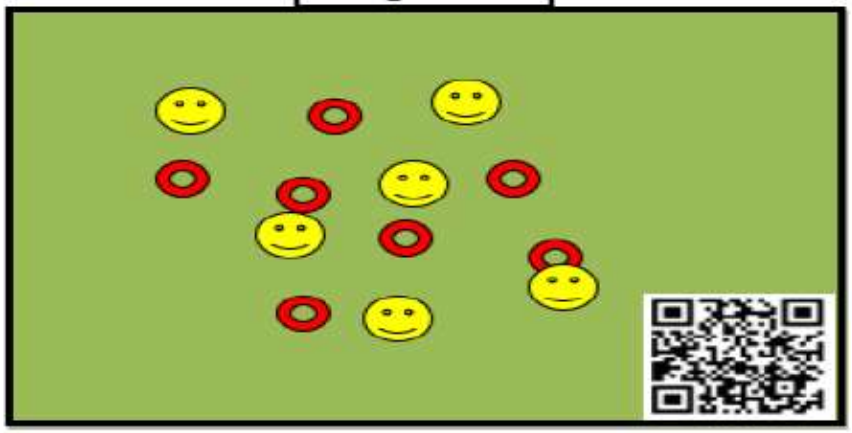
Basic Station

- Students skip for a distance of 10m – 20m.
- Focus on the step-hop rhythm, rather than performing the movement with speed.
- Ensure the arms are alternately moving in opposition to legs.

Students explore the skip using a range of the following:
- different distances between steps.
- keep feet low.
- spring to gain height.
- different arm positions.

Progression



- Students move around the area by skipping only. They must skip over a cone as they come to it and maintain the step-hop skipping technique while avoiding contact with other members of the group.
- Have students develop skipping patterns, changing direction, length of step and height of hop.

25

Skip

Arms alternately moving in opposition to legs.

Light springing steps

Step-hop rhythm

Arms swinging

Take off and land on the front of your foot

SKIP [TGMD]
(1) A rhythmical repetition of the step-hop on alternate feet.
(2) Foot of non-standing leg carried near surface during the hop phase.
(3) Arms alternately moving in opposition to legs at about waist level.

Activities and Sports for this Skill:

- GAA
- Athletics
- Basketball

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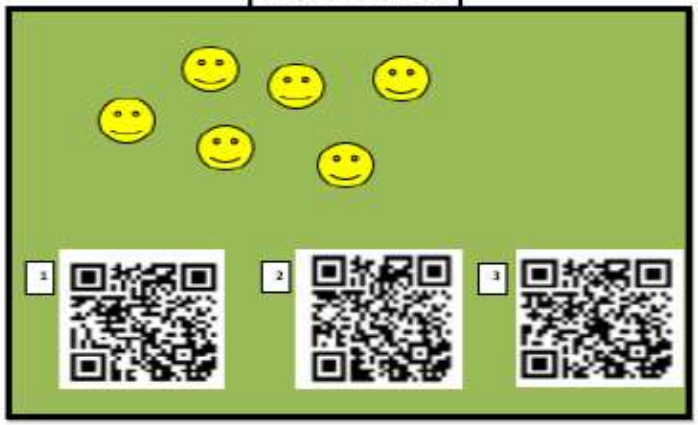
Vertical Jump

Basic Station



Encourage students to jump as high as possible.

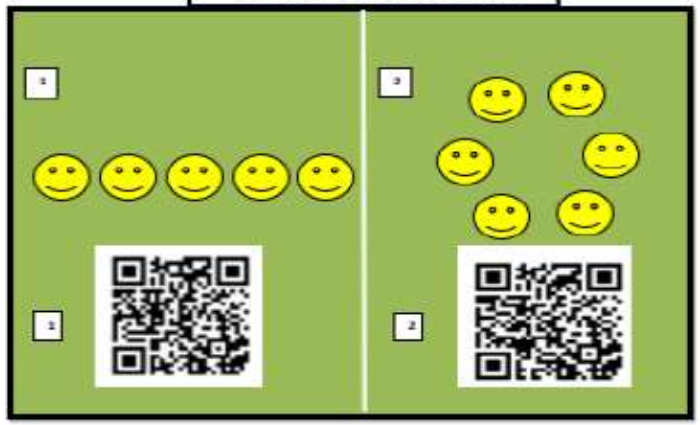
1) **Basic Vertical Jump**.

2) **Clap High Five (Vertical Jump)** to develop use of arms.

3) **Landing Technique and Reaction** to develop control of landings.

4) **Vertical Jump 'Time'**: Students always begin the vertical jump by facing 12.00 o'clock. The aim is to jump, turn in the air and execute a controlled landing with feet both facing a set hour on the clock.

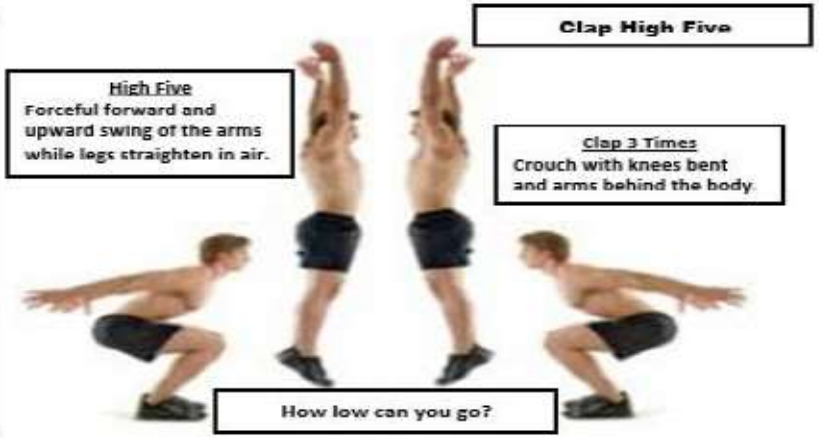
Various Progressions



1) **Mexican Wave Vertical Jump**: students line up in the aforementioned crouch position with knees bent and arms behind the body. A student at one end begins the 'Mexican Wave' by completing a vertical jump and the rest follow in suit like a domino effect.

2) **Mexican Wave Circle**: As above but this time students may change the direction of the 'Mexican Wave' by landing and facing in the opposite direction. The next student must try and react by using his/her peripheral vision while correctly executing the components of the vertical jump.

Vertical Jump



VERTICAL JUMP [GET SKILLED: GET ACTIVE]
(1) Eyes focused forward or upward throughout the jump.
(2) Crouch with knees bent and arms behind the body.
(3) Forceful forward and upward swing of the arms.
(4) Legs straighten in air.
(5) Land on balls of feet and bend knees to absorb landing.
(6) Controlled landing with ≤1 step any direction.

Vertical Jump 'Time'

Activities and Sports for this Skill:

- Basketball
- Volleyball
- Olympic Handball
- Circuits (HRF)
- Spikeball

Horizontal Jump

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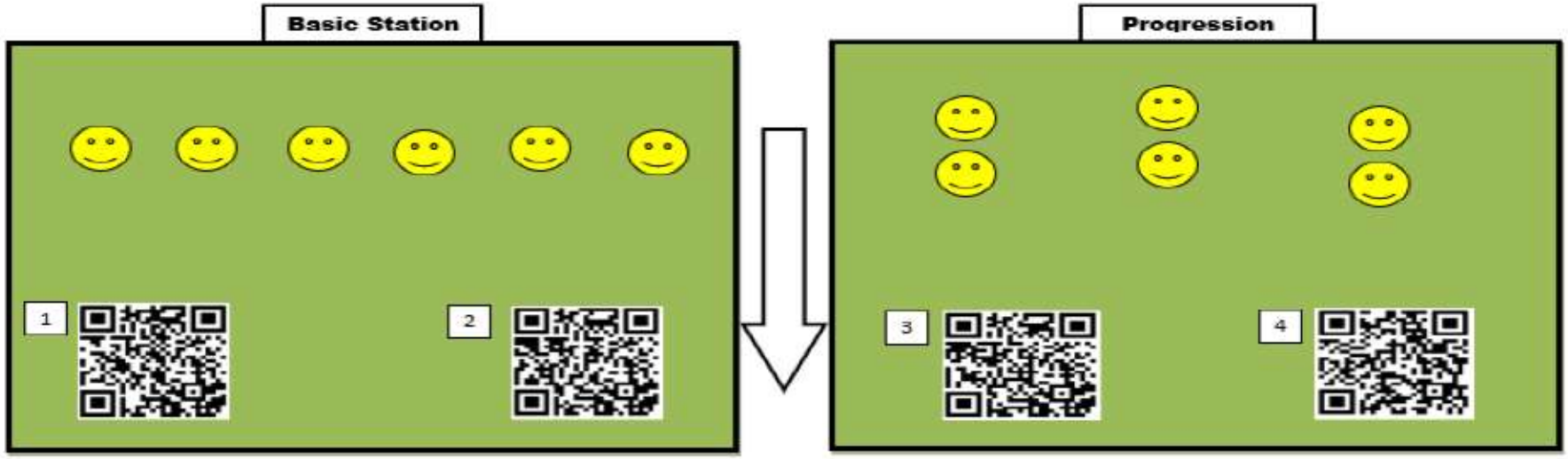

1) Basic Horizontal Jump.

2) Explore the horizontal jump:

- Experiment with different arm positions during the preparatory movement phase, flight phase and landing.

3) Students work with a partner [of similar ability]. The aim of this progression is for the partner behind (who starts approximately half a meter behind i.e. out of touching distance) to tag the partner in front. The partner in front does a horizontal jump as far as possible and holds in position. The partner behind then does a horizontal jump and aims to reduce the distance between the partners after each jump and tag the partner in front after a set number of jumps and/or within a set distance.

4) Horizontal Jump to Target

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Horizontal Jump

HORIZONTAL JUMP [TGMD-2]
(1) Preparatory movement includes bending of both knees with arms stretched out behind body.
(2) Arms reach forcefully forward and upward with full extension above the head.
(3) Take off and land on both feet together.
(4) Arms thrust downward during landing.

Activities and Sports for this Skill:

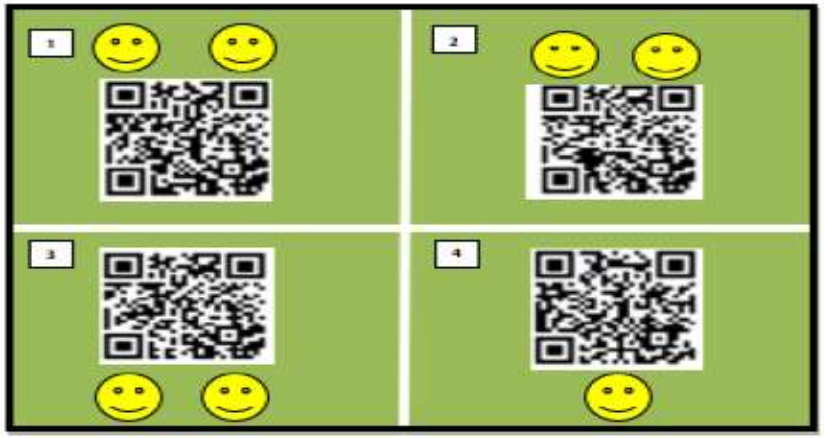
- Athletics (Long Jump) - Orienteering

Landing phase

Flight phase

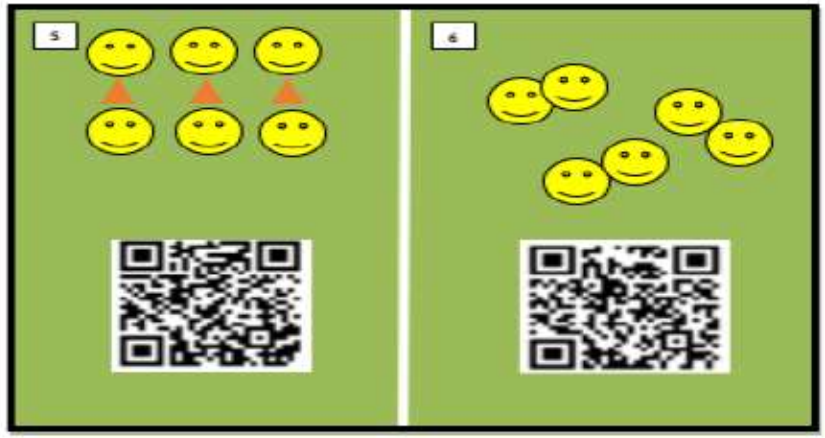
30

Deep Squat



Deep Squat preparatory movements and joint mobility:

1) Achilles Stretch (Ankle Mobility) for Deep Squat
2) Calf/Soleus Stretch for Deep Squat
3) Frog Squat
4) Bunny Hops



5) Deep Squat Cone Reaction Game. Students adopt a squat position facing a partner with a cone turned upside down between them. Maintaining the squat position, students are led by the 'caller' who shouts different parts of the body which students must touch (for example, head, hips, toes, nose etc.) until the caller shouts cone and the quickest person of each pair to grab it gets a point.

6) Deep Squat Thumb War Game. Students move around the area and adopt a squat position to play a game of 'Thumb War' before moving on and repeating the same again.

Deep Squat

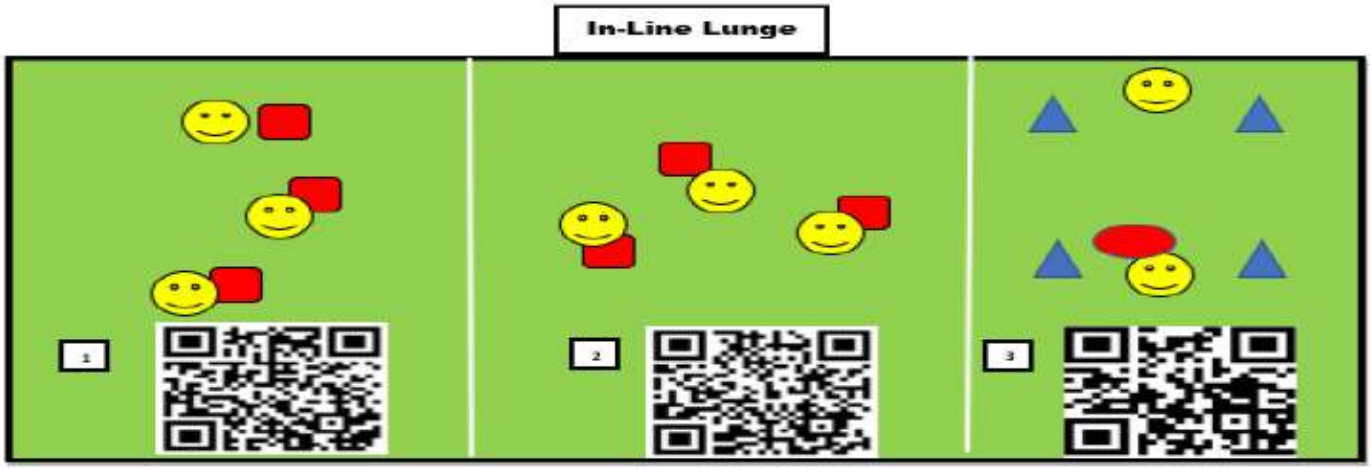
Activities & Sports for this skill: Rugby, Athletics, Weight-Lifting

Deep Squat

Toes pointing forward and shoulder width apart.

DEEP SQUAT
(1) Dowel maximally pressed overhead and aligned over feet. Note lumbar flexion.
(2) Toes point forward.
(3) Knees aligned over feet and knees do not go passed the toe line.
(4) Thighs break parallel with the floor on descent (i.e. femur below horizontal).

In-Line Lunge



1) **Beanbag Lunge 01**
2) **Beanbag Lunge 02**
   Explore different positions to place the beanbag during the lunge:
   below the knee that's lowering to the ground …
   on top of the head …
   on top of the brush handle or equivalent (as available) …
3) **In-Line Lunge Frisbee 03**-Explore passing a frisbee in a cooperative paired task, performing a lunge in the direction of the cone as they pass the frisbee

In-Line Lunge

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1

Keep body straight/upright

Keep both feet in-line
Eyes look straight ahead

Place foot outside the hand

Follow your fingers with your eyes

IN-LINE LUNGE
(1) Dowel remains in contact with head, [middle] back and backside.
(2) Dowel remains vertical.
(3) No body movement (i.e. balance is maintained).
(4) Knee touches board behind heel of front foot.
(5) The front heel remains in contact with the board and the back-heel touches board when returning to starting position.

Activities & Sport for this Skill:
Yoga, General Stretching for all sports

Active Straight Leg Raise

Hamstring Assisted Partner Stretch (Doorframe).

- One student lies flat on the ground or mat as appropriate. The partner (standing) then holds one leg in place upright (note: This should not cause pain or discomfort to the student on the ground). The student on the ground then lifts the leg on the ground up next to the leg being held upright and lowers it down again in a slow but controlled fashion. Repeat. Focus on breathing into the stretch also. Swap legs then swap roles.

Active Straight Leg Raise

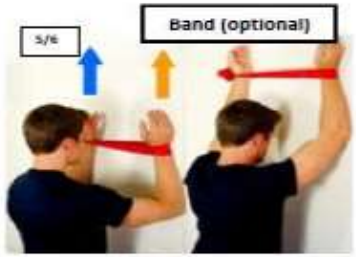
Activities & Sport for this skill: Dance, Gymnastics, All sport exercises in warm-up phase

ACTIVE STRAIGHT LEG RAISE
(1) Knee on floor remains touching the ground.
(2) Leg on floor does not turn outwards at the hip.

Shoulder Mobility

1) Shoulder Mobility 01 (Front and Back)
2) Shoulder Mobility 02 (Rowing)
3) Shoulder Mobility 03 (Press Up and Pull Down)
4) Shoulder Mobility 04 (Wall Angel)
5) Shoulder Mobility 05 (Wall Slides)
6) Shoulder Mobility 06 (V Slides)
7) Shoulder Mobility 07 (Windmill)

Shoulder Mobility

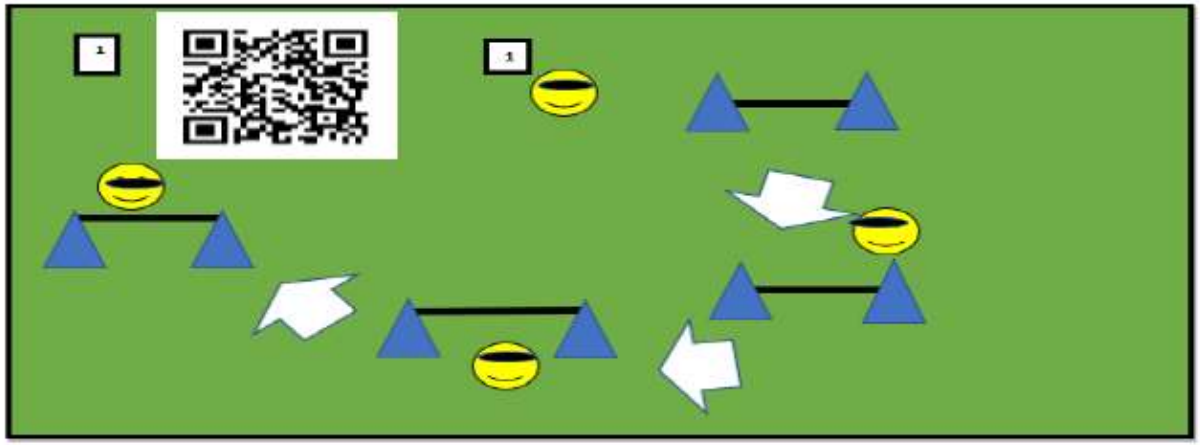


Activities & Sport for this skill: Weightlifting, General Stretching,

Brush Handle or equivalent

SHOULDER MOBILITY
(1) Does not walk hands towards each other (i.e. one single motion).
(2) Head remains in neutral position (i.e. looking straight ahead).

Hurdle Step



1) The Cube- Hurdle Step- An escalating challenge!

- Participants are blindfolded, (other students act as a guide)
- A series of cones and hurdles are laid out at varying heights. (No.1 is lowest, 4 is highest)
- Participants must hurdle step over these obstacles without knocking over the hurdles If they knock them over, they return to the start (Dowel is optional)
- As in the Cube TV show the game can be made easier as necessary

- **Progressions**

-Fastest time

-A point system (Deducted one point for knocking one, must try and complete a full round without knocking them)

Hurdle Step

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Activities & Sports for this Skill: Athletics

Over the gate!

Look Straight ahead

Up and Over the Gate!

Minimal movement in back

Grasp the Bar tight across the shoulders

Dowel and Hurdle Parallel to ground

Hurdle Step
(1)Hips, knees and ankles remain in one straight line
(2) Minimal Movement in the lower back
(3) Dowel remains in contact with shoulders
(4) Dowel remains parallel with Hurdle

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Trunk Stability Push-Up

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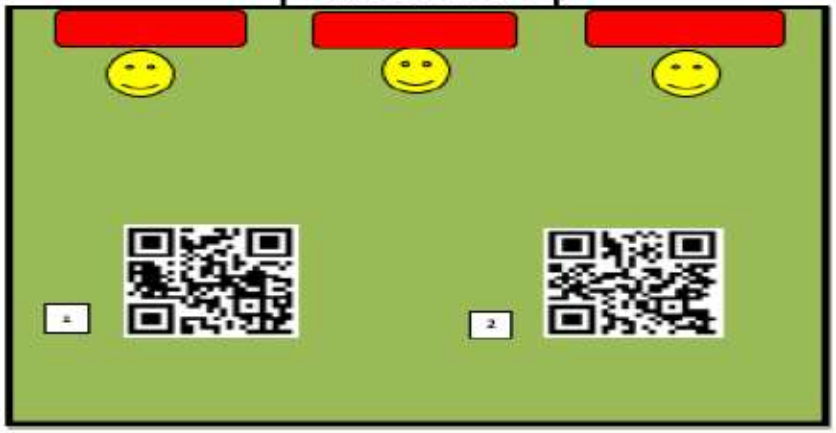
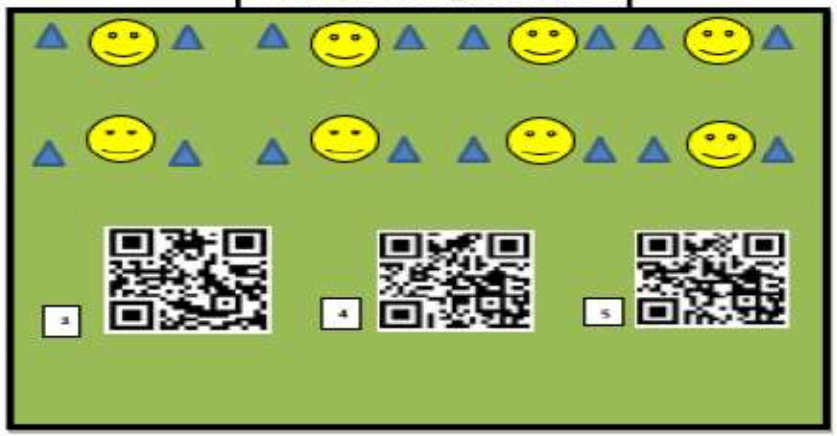
Basic Stations



1: Do a push up with knees in contact with ground (Incline Optional).

2: Step-Up boxes are used as an incline surface on which students do push ups. *Ensure students are not leaning on the edge of the Step-Up box as it may topple over.

Various Progressions



3: 1V1. Students do a push up before each attempt to roll ball into opponent's goal. Hold Position between shots.

4: Starting 1m apart, each student must do a push up before each forward movement. You must catch the other player before they reach the end line.

5: Students perform forward moving caterpillar push-ups and attempt to catch the person in front of them before they reach the finish line. Evader has a 1.5m head start.

Trunk Stability Push-Up

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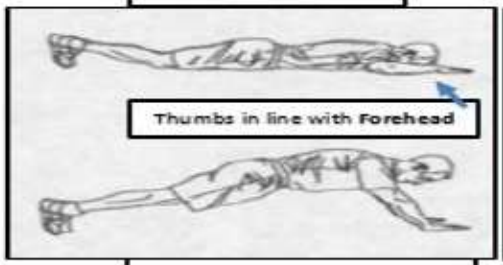
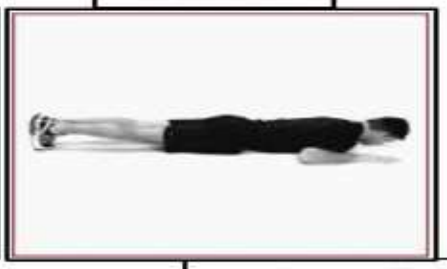
Males



Females



TRUNK STABILITY PUSH-UP

(1) Body lifts as one unit.

Knee Push-Ups

Incline Push-Ups

Caterpillars

Activities and Sports for this Skill:

-Circuits (HRF)

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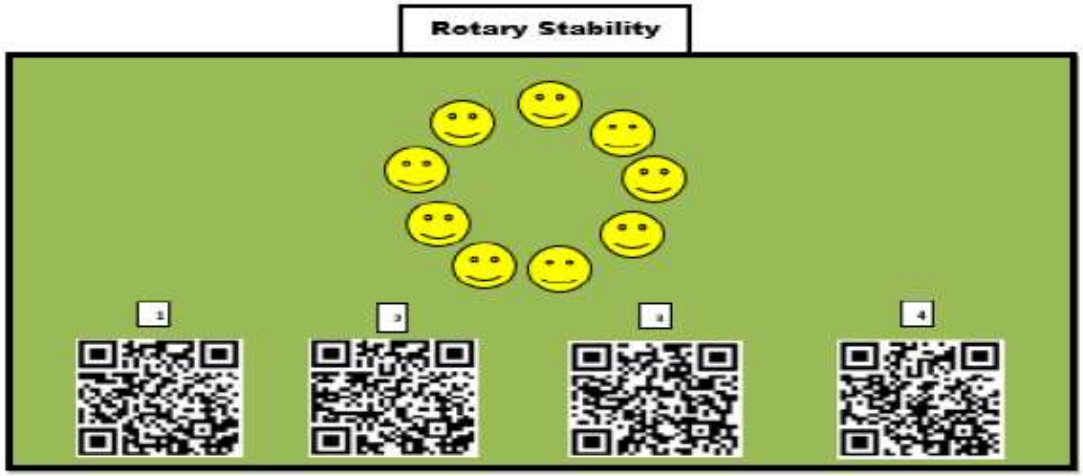
Rotary Stability



1) **Spiderman Rotation 01**

2) **Spiderman Rotation 02**

Complete 5-10 repetitions on both hands before switching leg positions.

3) **Superman Kneeling**

Complete 5-10 repetitions using opposite arm and leg (i.e. right arm stretched forward and left leg stretched back, then switch sides) before attempting same arm and leg.

4) **Superman Standing**

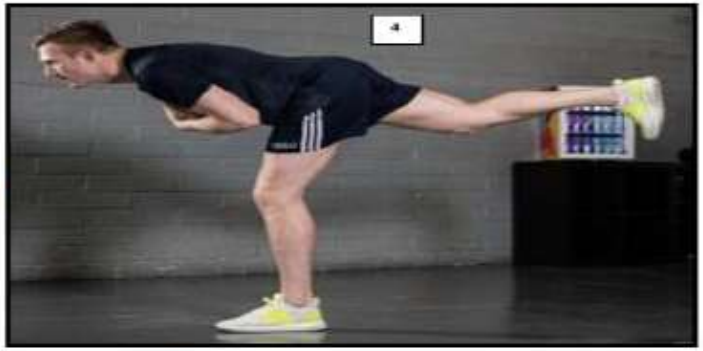
Rotary Stability

Place foot outside the hand

Follow your fingers with your eyes

2

4



ROTARY STABILITY
(1) Ankles with toes tucked under (i.e. dorsiflexion).
(2) Back remains flat/parallel to board).

same arm, same leg.

Activities and Sports for this Skill:

-Circuits (HRF)

-Yoga

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Multi-Movement Activities

These Activities develop Movement Capabilities across a number of Movement Patterns

Superman Standing	Reach, Roll & Lift	Downward Dog - Cobra (Yoga)
Spiderman Rotation	Trunk Twists	Prisoner Game

Kinaesthetic Classroom Breaks

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Project FLAME – Kinaesthetic Classroom Breaks

With Physical Education time only timetabled for a double period a week during Junior Cycle, attempting to introduce physical activity in non-traditional classroom settings is becoming a popular alternative. Promoting the need to be active and cognisant of one's health, and health-related behaviour is extremely important as 'Student Wellbeing' becomes a priority within education. To supplement Physical Education lessons, we have devised 'Kinaesthetic Classroom' breaks which enable students to get active within most classroom settings. Our teacher Diarmuid provides simple audio cues and a visual demonstration for students to replicate. Teachers are encouraged to provide support and encouragement to students in an effort to get them to engage with the activity. Currently, seven videos have been developed as part of our resource pack. We are looking to expand on these videos over time, and welcome feedback on the current videos, as well as any ideas you may have for activities for use in the classroom .

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Kinaesthetic Classroom Breaks

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Project FLAME – Kinaesthetic Classroom Breaks

01- Hip Twists

02- Chair Squats

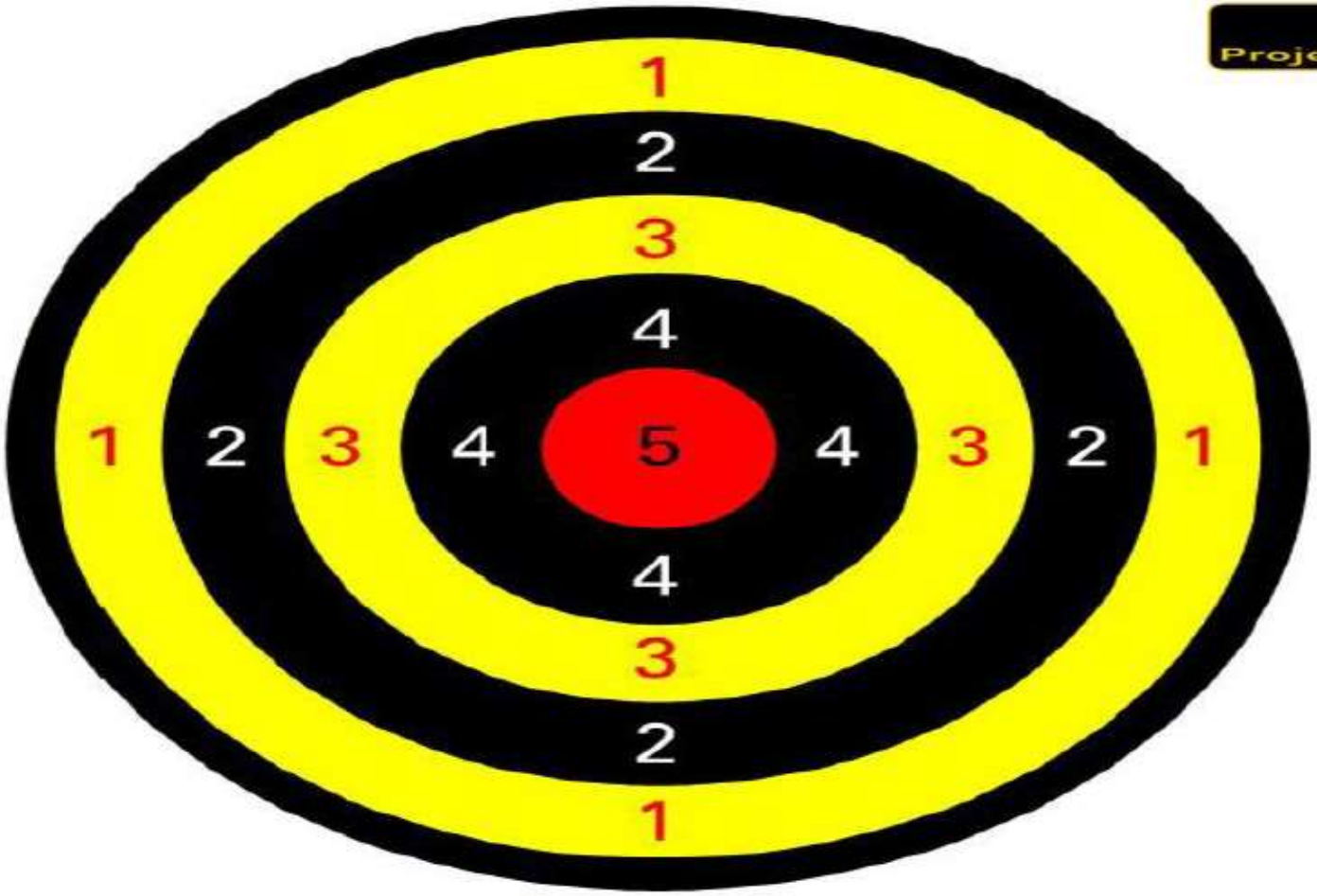
03- Vertical Jump

04- Balance

05- Running and Skipping

06- Lunge

07- Landing Technique



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6.2.5 Appendix E: Project FLAME Suggested Schedule

The Project FLAME Intervention Teacher Guidelines

A portion of the class will be devoted to work on these skills and patterns in each week. Here is a sample programme we have devised. It is not prescriptive, merely suggestive. To emphasise movement and skills in general, we encourage you to introduce movements that may not necessarily be associated with the sport or activity you are covering in PE lessons (e.g. at the start of a lesson for soccer, you could have a throwing element in the warm-up phase). In this sense, you are creating a movement skills phase of a lesson, which students can be made aware of.

The purpose of this phase is to develop the students' cognitive knowledge of the movement (i.e. skill cues) and improve psychomotor capabilities (i.e. improve skill performance). Some of these skills/patterns are implicit in many elements of activity, as such the key cues can be repeated across the weeks. (e.g. run and skip are central to many forms of activity). The first time you engage in a skill/movement pattern we recommend using our basic stations, or similarly aligned activities.

Sample 8-Week Intervention Programme

Week 1	Throw/Catch, Balance
Week 2	Trunk Stability Push-Up, Shoulder Mobility, & Rotary Stability
Week 3	Deep Squat, Vertical Jump & Horizontal Jump,
Week 4	Hurdle Step, Run, & Skip
Week 5	Active Straight Leg Raise, Kick, & In-Line Lunge

Week 6	Dribble, Rotary Stability, & Trunk Stability Push-Up
Week 7	Strike, Throw & Deep Squat
Week 8	Vertical Jump & Horizontal Jump, Active Straight Leg Raise,

6.2.6 Appendix F: Project FLAME Research Assistant Handbook

Data Collection Checklist – Project FLAME

GENERAL GUIDELINES:

Press **RECORD** at the start of each group and **STOP** the camera at the end of each group.

Call out the **ID CODE** of the student at the start of each skill/movement, for example, 'SA131 Practice'; 'SA131 Trial 1'; 'SA131 Trial 2'.

Give **NO FEEDBACK** to students during any of the tests.

Ensure the camera is in a fixed position i.e. on a tripod, on a table etc. **DO NOT** hold the camera by hand as it can be difficult to assess the skill/movement if there is any disturbance/shaking.

Ensure that you follow the list of the participants within their group in **ORDER** of their ID code.

If there are any issues or problems call over the **FLOATING RESEARCHER** (Wesley, Brian or Conor) for help.

FUNDAMENTAL MOVEMENT SKILLS (FMS):

3 attempts at each skill (1 practice followed by 2 trials)

It is very important that the **DEMONSTRATION** of the skill is performed correctly by the researcher and that **ALL** students are paying attention to the demonstration. Instruct the students to repeat/copy exactly what the researcher has demonstrated.

Be strict with students to a degree by not allowing them to begin the practice or trial until you have given them the signal etc.

Ask students if they are **LEFT-HANDED** for the **THROW** and **STRIKE** and if they use with their **LEFT FOOT** for the **KICK**. If so, move the camera to the opposite side. Note that the use of the baseball grip can be confusing so let students feel it out themselves and only adjust the camera if students position themselves in that way.

TWO HANDED CATCH – Ensure the researcher is the one who throws the tennis ball to the student for this skill. Throw the ball underarm and slightly in front of the student to allow them to reach to collect it as opposed to throwing the tennis ball directly at/to them.

HORIZONTAL/VERTICAL JUMP – Begin with feet side by side and shoulder width apart. Use a line on the floor as the mark.

THROW – Instruct students to throw the beanbag as **HARD** as they can at the target wall.

Fundamental Movement Skill Testing Descriptions:

Run

Skill	Materials	Directions	
1. Run	60 feet of clear space, and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial.	1. Arms move in opposition to legs, elbows bent 2. Brief period where both feet are off the ground 3. Narrow foot placement landing on heel or toe (i.e., not flat footed) 4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks)

Striking a stationary ball

Skill	Materials	Directions	
1. Striking a Stationary Ball	A 4-inch lightweight ball, a plastic bat, and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial.	1. Dominant hand grips bat above nondominant hand 2. Nonpreferred side of body faces the imaginary tosser with feet parallel 3. Hip and shoulder rotation during swing 4. Transfers body weight to front foot 5. Bat contacts ball

Catch

Skill	Materials	Directions	Performance Criteria
3. Catch	A 4-inch plastic ball, 15 feet of clear space, and tape	Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial.	1. Preparation phase where hands are in front of the body and elbows are flexed 2. Arms extend while reaching for the ball as it arrives 3. Ball is caught by hands only

Kick

Skill	Materials	Directions	
4. Kick	An 8- to 10-inch plastic, playground, or soccer ball; a beanbag; 30 feet of clear space; and tape	Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the bean-bag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid continuous approach to the ball 2. An elongated stride or leap immediately prior to ball contact 3. Nonkicking foot placed even with or slightly in back of the ball 4. Kicks ball with instep of preferred foot (shoe-laces) or toe

Horizontal Jump

Skill	Materials	Directions	Performance Criteria
5. Horizontal Jump	A minimum of 10 feet of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he or she can. Repeat a second trial.	1. Preparatory movement includes flexion of both knees with arms extended behind body 2. Arms extend forcefully forward and upward reaching full extension above the head 3. Take off and land on both feet simultaneously 4. Arms are thrust downward during landing

Overhand Throw

Skill	Materials	Directions	Performance Criteria
5. Overhand Throw	A tennis ball, a wall, tape, and 20 feet of clear space	Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	1. Preparation phase where hands are in front of the body and elbows are flexed 2. Arms extend while reaching for the ball as it arrives 3. Ball is caught by hands only

Stationary Dribble

Skill	Materials	Directions	
2. Stationary Dribble	An 8- to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat, hard surface	Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand at about belt level 2. Pushes ball with fingertips (not a slap) 3. Ball contacts surface in front of or to the outside of foot on the preferred side 4. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it

Balance

1 2 3 4 5

1 3 4

1. Support leg still, foot flat on the ground.
2. **Non-support leg bent, not touching the support leg.**
3. **Head stable, eyes focused forward.**
4. **Trunk stable and upright.**
5. No excessive arm movements.

Balance Continued: Participants are asked to balance on one leg with arms stretched out to the sides of their body.

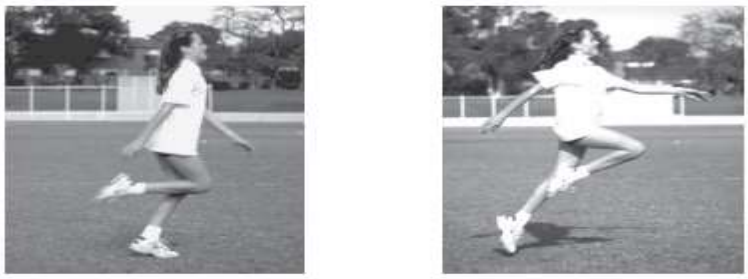
Vertical Jump

1 2 3 4 5 6

1. **Eyes focused forward or upward throughout the jump.**
2. **Crouches with knees bent and arms behind the body.**
3. Forceful forward and upward swing of the arms.
4. Legs straighten in the air.
5. Lands on balls of the feet and bends knees to absorb landing.
6. Controlled landing with no more than one step in any direction.

Skip-TGMD-1 (PHOTO credit- Get Skilled Get Active)

1 3 4



1. **Shows a rhythmical step-hop.**
2. Lands on ball of the foot.
3. Knee of support leg bends to prepare for hop.
4. **Head and trunk stable, eyes focused forward.**
5. **Arms relaxed and swing in opposition to legs.**

Skip: The Skip is performed on the same 20m length track as the Run. In your demonstration, ensure that your arms and legs move in opposition

Camera Positions for FMS (Front; Side):

Balance = Front	**Catch = Side**
Dribble = Front	**Horizontal Jump =Side**
Kick = Side	**Run = Side**
Skip = Side	**Strike = Side**
Throw = Side	**Vertical Jump = Side**

Fundamental Movement Skills (FMS)

Performance Criteria – Simplified Language

BALANCE [GET SKILLED: GET ACTIVE]
(1) Standing leg still, foot flat on the ground.
(2) Non-standing leg bent back behind at the knee, not touching the standing leg.

(3) Head stable, eyes focused forward.
(4) Body stable and upright.
(5) Arms stretched out wide at the sides with no excessive movements.
CATCH [TGMD-2]
(1) Preparation phase where hands are in front of the body and elbows are bent.
(2) Arms reach out for the ball as it arrives.
(3) Ball is caught by both/two hands only.
DRIBBLE [TGMD-2]
(1) Contacts ball with one hand at about waist level.
(2) Pushes ball with fingertips (not a slap).
(3) Ball contacts surface in front of or to the outside of foot on preferred side.
(4) Maintains control of ball for four bounces in a row without having to move the feet to retrieve it.

HORIZONTAL JUMP [TGMD-2]
(1) Preparatory movement includes bending of both knees with arms stretched out behind body.
(2) Arms reach forcefully forward and upward with full extension above the head.
(3) Take off and land on both feet together.
(4) Arms thrust downward during landing.

KICK [TGMD-2]
(1) Rapid continuous approach to the ball.
(2) An elongated stride or leap immediately prior to ball contact.
(3) Non-kicking foot placed even with (to the side) or slightly behind the ball.
(4) Kicks ball with instep of preferred foot (shoelaces) or toe.
RUN [TGMD-2]
(1) Arms alternately moving in opposition to legs, elbows bent.
(2) Brief period where both feet are off the ground.
(3) Narrow foot placement landing on heel or toe.
(4) Non-standing leg bent approximately 90 degrees.
SKIP [TGMD]
(1) A rhythmical repetition of the step-hop on alternate feet.
(2) Foot of non-standing leg carried near surface during the hop phase.
(3) Arms alternately moving in opposition to legs at about waist level.

STRIKE [TGMD-2]
(1) Dominant hand grips bat above non-dominant hand (as the bat is pointing up).
(2) Non-preferred side of body faces the imaginary thrower with feet shoulder width apart.

(3) Hip and shoulder rotate/turn during swing.
(4) Transfers body weight to front foot.
(5) Bat contacts ball.
THROW [TGMD-2]
(1) Wind-up is initiated with downward movement of hand/arm.
(2) Rotates hip and shoulder to a point where the non-throwing side faces the wall.
(3) Weight is transferred by stepping with the foot opposite the throwing hand.
(4) Follow-through with hand beyond ball release diagonally across the body towards the nonpreferred side.
VERTICAL JUMP [GET SKILLED: GET ACTIVE]
(1) Eyes focused forward or upward throughout the jump.
(2) Crouch with knees bent and arms behind the body.
(3) Forceful forward and upward swing of the arms.
(4) Legs straighten in air.
(5) Land on balls of feet and bend knees to absorb landing.
(6) Controlled landing with ≤1 step any direction.

FUNCTIONAL MOVEMENT SCREEN (FMS™):

3 attempts at each movement.

The researcher is **NOT** required to **DEMONSTRATE** the movement, however, do show them the starting position to save time and explain what they will be doing from there to successfully complete the movement.

Note that **FIVE** of the seven tests of the Functional Movement Screen must be assessed on both right and left sides of the body, namely the Active Straight Leg Raise, Hurdle Step, In-Line Lunge, Rotary Stability and Shoulder Mobility.

ROTARY STABILITY – Get students to adjust the side of their body facing the camera for right and left sides accordingly as opposed from the tester adjusting the camera. Begin with the score of '2' movement and if successful instruct students to attempt the '3' (i.e. same arm same leg) and 6 inches or so off the ground is sufficient.

The Functional Movement Screen (FMS™)

Performance Criteria adopted from FMS™ – Simplified Language

ACTIVE STRAIGHT LEG RAISE (Right and Left)
(1) Knee on floor remains touching the ground.
(2) Leg on floor does not turn outwards at the hip.
Testing Protocol: • Lay flat with the back of your knees against the 2x6 with your toes pointing up. • Place both arms next to your body with the palms facing up. • Pull the toes of your right foot toward your shin. • With the right leg remaining straight and the back of your left knee maintaining contact with the 2x6, raise your right foot as high as possible.

DEEP SQUAT
(1) Dowel fully pressed overhead and aligned over feet.
(2) Toes point forward.
(3) Knees aligned over feet and knees do not go passed the toe line.
(4) Thighs break parallel with the floor on the way down.
Testing Protocol: Stand tall with your feet approximately shoulder width apart and toes pointing forward. • Grasp the dowel in both hands and place it horizontally on top of your head so your shoulders and elbows are at 90 degrees. • Press the dowel so that it is directly above your head. • While maintaining an upright torso, and keeping your heels and the dowel in position, descend as deep as possible. • Hold the descended position for a count of one, then return to the starting position. • The participant can perform the move up to three times total if necessary. If a score of three is not achieved, repeat above instructions using the 2 x 6 under the client's heels.
HURDLE STEP
(1) Hips, knees and ankles aligned.
(2) Maintains a stable body with minimal to no movement in lower back.
(3) Dowel and hurdle remain parallel.
(4) Foot and/or heel touches the floor while standing leg remains in extended position.
(5) No contact between foot and hurdle.
Testing Protocol: • Stand tall with your feet together and toes touching the test kit. • Grasp the dowel with both hands and place it behind your neck and across the shoulders.

• While maintaining an upright posture, raise the right leg and step over the hurdle, making sure to raise the foot towards the shin and maintaining foot alignment with the ankle, knee and hip. • Touch the floor with the heel and return to the starting position while maintaining foot alignment with the ankle, knee and hip.
IN-LINE LUNGE
(1) Dowel remains in contact with head, [middle] back and backside.
(2) Dowel remains vertical.
(3) No body movement (i.e. balance is maintained).
(4) Knee touches board behind heel of front foot.
(5) The front heel remains in contact with the board and the back heel touches board when returning to starting position.
Testing Protocol: • Place the dowel along the spine so it touches the back of your head, your upper back and the middle of the buttocks. • While grasping the dowel, your right hand should be against the back of your neck, and the left hand should be against your lower back. • Step onto the 2x6 with a flat right foot and your toe on the zero mark. • The left heel should be placed at _____mark. This is the tibial measurement marker. • Both toes must be pointing forward, with feet flat. • Maintaining an upright posture so the dowel stays in contact with your head, upper back and top of the buttocks, descend into a lunge position so the right knee touches the 2x6 behind your left heel. • Return to the starting position.
ROTARY STABILITY
(1) Ankles with toes tucked under (i.e. dorsiflexion).
(2) Back remains flat/parallel to board).

Testing Protocol:

• Get on your hands and knees over the 2x6 so your hands are under your shoulders and your knees are under your hips.
• The thumbs, knees and toes must contact the sides of the 2x6, and the toes must be pulled toward the shins.
• At the same time, reach your right hand forward and right leg backward, like you are flying.
• Then without touching down, touch your right elbow to your right knee directly over the 2x6.
• Return to the extended position.
• Return to the start position.

SHOULDER MOBILITY

(1) Does not walk hands towards each other (i.e. one single motion).

(2) Head remains in neutral position (i.e. looking straight ahead).

Testing Protocol:

• Stand tall with your feet together and arms hanging comfortably.
• Make a fist so your fingers are around your thumbs.
• In one motion, place the right fist overhead and down your back as far as possible while simultaneously taking your left fist up your back as far as possible.
• Do not "creep" your hands closer after their initial placement.

TRUNK STABILITY PUSH-UP

(1) Body lifts as a unit with no delay in lower back when performing the push-up.

(2) Ankles with toes tucked under (i.e. dorsiflexion) in both the preparatory and performance phases of the movement.

Testing Protocol:

• Lie face down with your arms extended overhead and your hands shoulder width apart.
• Pull your thumbs down in line with the ___ (forehead for men, chin for women).
• With your legs together, pull your toes toward the shins and lift your knees and elbows off the ground.
• While maintaining a rigid torso, push your body as one unit into a push up position.

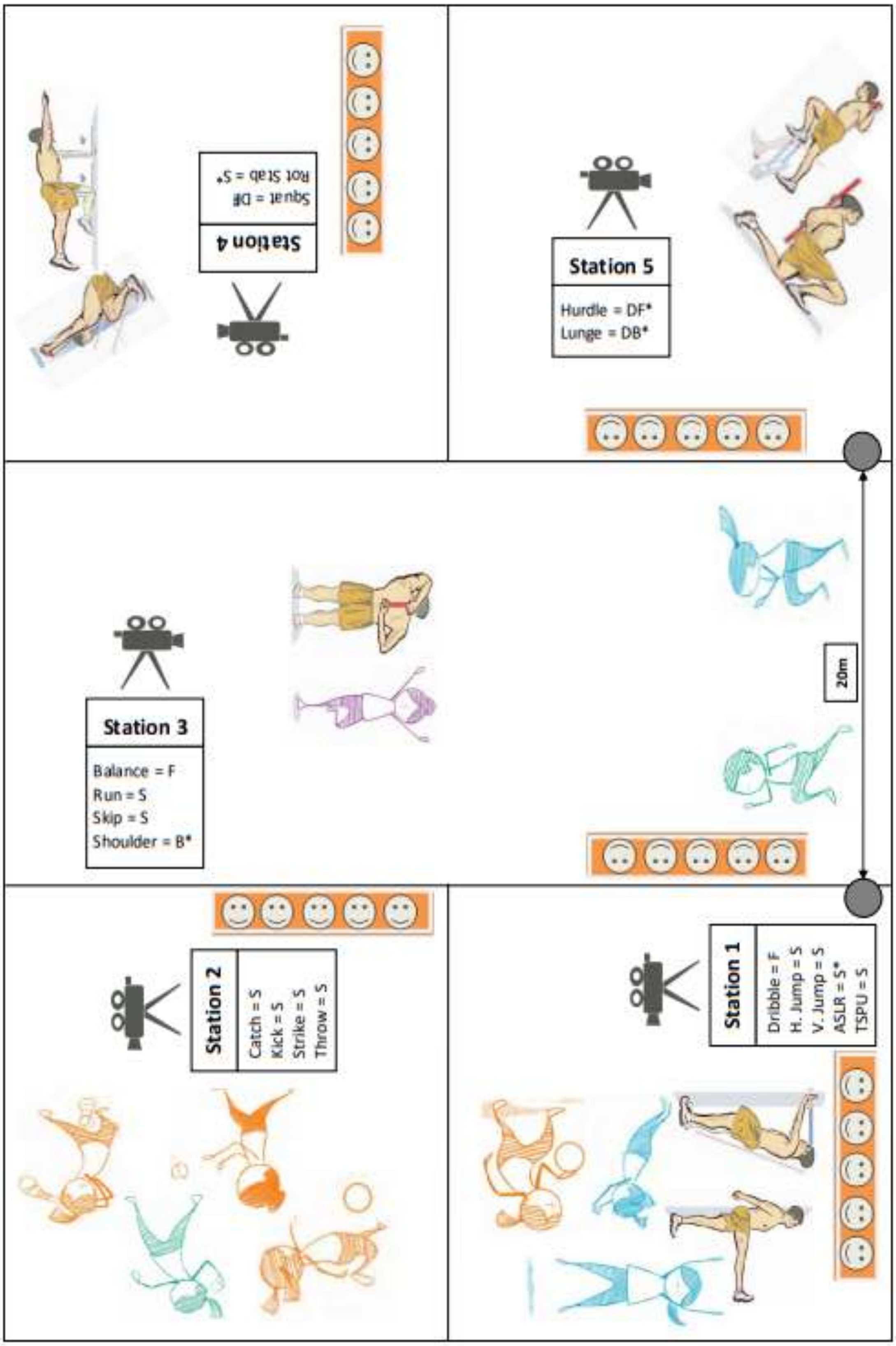
Camera Positions for FMS™:

Active Straight Leg Raise = Side **Deep Squat = Side**

Hurdle Step = Diagonally Front **In-Line Lunge = Diagonally Behind**

Shoulder Mobility = Behind **Rotary Stability = Side**

Trunk Stability Push Up = Side



*S = Side; F = Front; B = Behind; DF = Diagonally Front; DB = Diagonally Behind; * = Test Left and Right Sides*